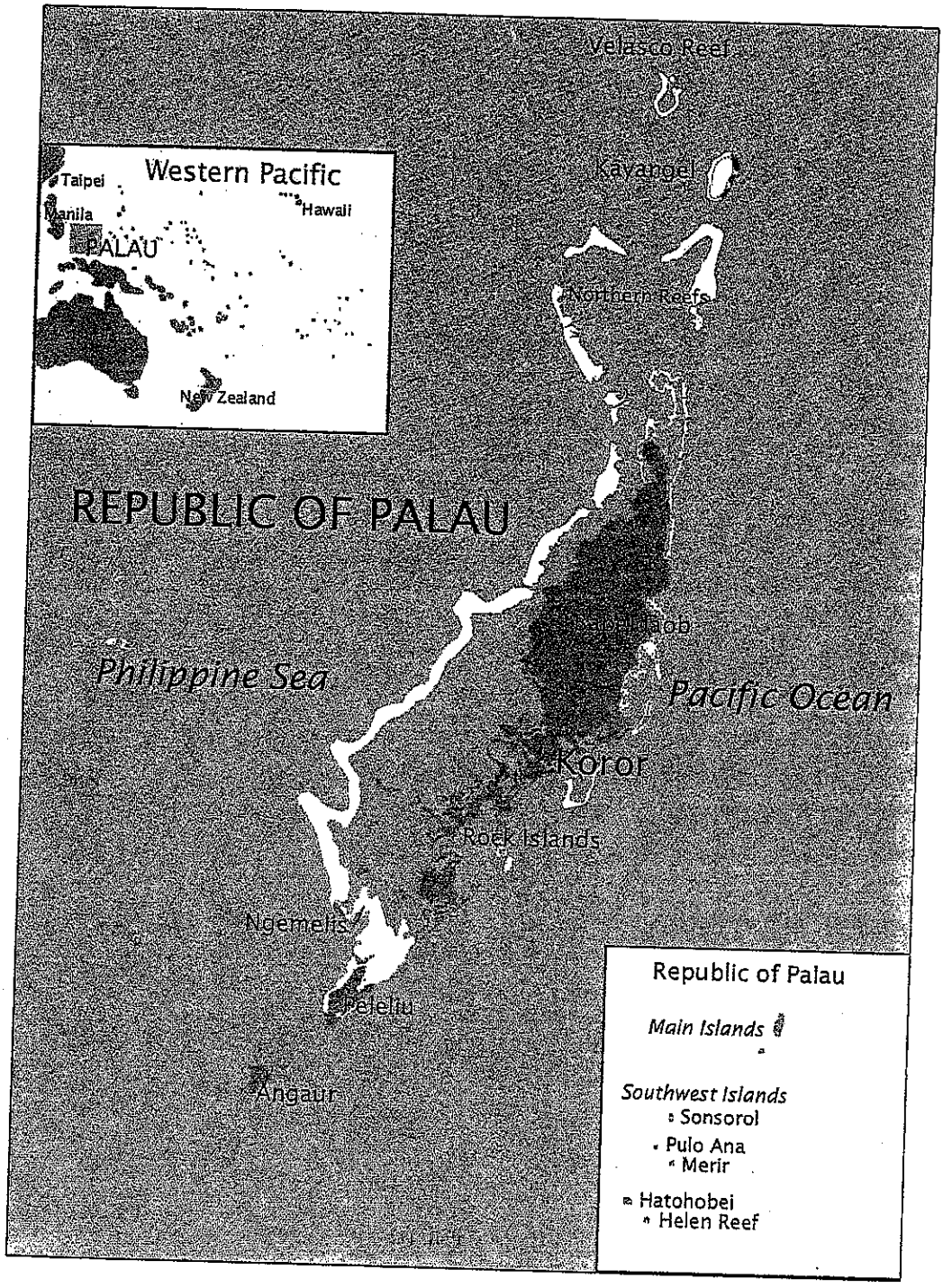
REPUBLIC OF PALAU

1NC-PLW02

First National Communication to the United Nations Framework Convention on Climate Change

REPUBLIC OF PALAU

First National
Communication
to the
United Nations Framework
Convention on
Climate Change



Office of Environmental Response and Coodination, Office of the President of the Republic of Palau, 2002
Published 2002 by the Office of Environmental Response and Coordination
P.O. Box 7086, Koror, PW 96940, REPUBLIC OF PALAU

Table of Contents

FORWARD ix

EXECUTIVE SUMMARY x

NATIONAL CIRCUMSTANCES

1.1 Geography 1

1.2 History 3

1.3 Climate 4

1.3.1 Temperature 4

1.3.2 Rainfall 5

1.3.3 Current and Tides 5

1.3.4 ENSO Events 6

1.3.5 Typhoons 7

1.4 Biological Diversity 7

1.4.1 Mangrove Forests 8

1.4.2 Seagrass Beds 9

1.4.3 Coral Reefs 9

1.4.4 Reef and Freshwater Fishes 10

1.4.5 Marine Reptiles 11

1.4.6 Marine Mammals 12

1.4.7 Lake Systems 12

1.4.8 Terrestrial Forests 14

1.5 Population 15

1.6 Socio-Cultural Characteristics 16

1.6.1 Tradition 16

1.6.2 Social System 17

1.7 Transportation 17

1.8 Energy Sector 18

1.9 Water Resources 19

1.9.1 Usage 20

1.10 Agriculture 20

1.10.1 Import Dependency 21

1.11 Health 22

1.12 Economy 22

1.12.1 Compact of Free Association 22

1.12 Tourism 23

1.13 Fisheries 24

Pteropus mariannus pelewenses - Palau's endemic fruit bat is common throughout the entire archipelago. It continues to be a traditional part of the Palauan diet as a source of protein.

NATIONAL GREENHOUSE GAS INVENTORY

2.1 Introduction . . . 26
2.2 Methodology, Assumptions, and Data . . . 26
2.3 Results and Analysis . . . 26
2.4 Quality Assurance . . . 27
2.5 Uncertainties . . . 27
2.6 Greenhouse Gas Emissions by Sector . . . 27
2.6.1 Emissions from the Energy Sector . . . 28
2.6.2 Emissions from Industrial Processes . . . 29
2.6.3 Emissions from the Agricultural Sector . . . 29
2.6.4 Emissions from Land Use Change and Forestry . . . 30
2.6.5 Emissions from Waste . . . 30
2.7 Comparison with Other Countries . . . 30
2.8 Data Gaps . . . 31
2.8.1 Energy Sector . . . 32
2.8.2 Industrial Processes . . . 32
2.8.3 Agriculture . . . 33
2.8.4 Land-Use Change and Forestry . . . 33
2.8.5 Waste . . . 34

GREENHOUSE GAS MITIGATION

3.1 Introduction . . . 35
3.1.1 Economic Factors . . . 35
3.1.2 Political Factors . . . 35
3.2 Energy Demand and Use . . . 35
3.2.1 Demand Side Options . . . 36
3.2.2 Supply Side Options . . . 37
3.3 Promotion of Carbon Sinks . . . 38
3.4 Solid Waste Management . . . 38
3.5 Coral Reefs . . . 39
3.6 Capacity Building . . . 39
3.6.1 Human Resources Development . . . 40
3.6.2 Cross-Sectoral and Cross-Institutional Strengthening . . . 40
3.6.3 National Greenhouse Gas Inventory Manual . . . 40

Manta birostris - This is one of the largest fishes common to Palau's inshore waters. This species is especially numerous during the first quarter of the year and is a major ecotourism draw.

3.6.4 Awareness Raising and Participation 40
3.6.5 Integrated Assessment of Environmental Pressures 41

Bufo marinus - The common invasive toad is found throughout Palau. The toads' population fluxuates dramatically with climate variations.

VULNERABILITY TO CLIMATE CHANGE

4.1 Introduction 42
4.2 Vulnerability Assessment 44
4.3 Methodology 52
4.4 Climate Change and Sea Level Rise Scenarios 52
4.4.1 Increased Drought and Storm Activity 56
4.4.2 Extreme High Tides 57
4.4.3 Sea Level Rise 59
4.4.4 Sea Surface Temperature and Coral Bleaching 59

ADAPTATION TO CLIMATE CHANGE

5.1 Introduction 65
5.2 Agriculture 65
5.2.1 Susceptible Areas 65
5.2.2 Invasive Species 66
5.2.3 Incentive Measures 67
5.3 Coastal Systems 67
5.3.1 Foreshore Protection 67
5.3.2 Pollution Control 68
5.3.3 Resettlement 68
5.4 Living Marine Resources 68
5.4.1 Monitoring and Enforcement 68
5.5 Biodiversity 69
5.6 Water Resources 70
5.7 Human Health 71
5.8 Housing 72
5.9 Policies and Planning 72
5.9.1 National Policy Framework 72
5.9.2 Capacity Building 73
5.9.3 Public Awareness and Education 73

Myiagra Erythrilops - The Palau Flycatcher, an endemic forest bird has a healthy population estimated at over 40,000.

RESPONSE TO CLIMATE CHANGE

6.1 Introduction 7

6.2 National Implementation Strategy 7

Figures, Graphs, Maps

Figures

Figure 1.1 Terrestrial and Marine Species List

Figure 1.2 Terrestrial Vertebrate Endemic Fauna

Figure 1.3 Alien Terrestrial Fauna

Figure 1.4 Palau's Major Economic Indicators

Figure 1.5 Palau's Tourism Arrival Trends for the Period between 1994-2000

Figure 2.1 Completeness of Data for Palau's Greenhouse Gas Inventory

Figure 2.2 Integrated Inventory of Annual Emissions for Palau in 1994

Figure 2.3 Apparent Domestic Consumption of Fuel and Associated CO_2 Emissions in 1994

Figure 2.4 Quantities involved in Soda Ash Use, Road Paving with Asphalt, and with Alcoholic Beverage, Bread and other Food Production, and the Associated Emissions of Greenhouse Gases

Figure 2.5 Emissions Related to Agricultural Activities

Figure 2.6 Annual Removals of Atmospheric Carbon Associated with Land-Use Change in Palau and Selected Other Pacific Island Countries

Figure 2.7 Emissions Associated with Waste and Waste Treatment in Palau and Selected Other Pacific Island Countries

Figure 2.8 CO_2 Emissions form the Energy Sector in Comparison with the World

Figure 4.1 Sectors and Case Studies Analyzed by the Vulnerability and Adaptation Team

Figure 4.2 Projected Incremental Change, from 1990 to 250 and to 2100 in Mean Annual Temperature from the Area Surrounding Palau

Figure 4.3 Seasonal Rainfall Variations in Palau During El Nino

Figure 4.4 Taro Loss During the 1998 High Tide Event

Graphs

Graph 1.1 Sea Surface Temperature Increase in 1998

Graph 1.2 Natural Variation in Water Temperature Overtime

Graph 2.1 Estimated CO_2 Emissions from Palau's Energy Sector in 1994

Graph 2.2 Estimated Methane Emissions from Palau's Solid Waste Disposal Site in 1994

Graph 2.3 Estimated Carbon Uptake Due to Changes in Forest and other Wood Biomass stocks in 1994

Graph 2.4 Emissions of CO_2 in 1994 Associated with Domestic Consumption of Fuels

Graph 2.5 Annual CO_2 Emissions by Fuel Type for 1994-2000 Inclusive

Graph 2.6 Annual Emissions of CO_2 by the Energy Sector for 1994-2000 Inclusive

Many species of native flora found throughout the islands are at risk from the affects of climate change and the introduction of invasive species.

Pyrroglaux podargina - The Palau owl is rare endemic often heard during the early evenings throughout the islands.

Graph 2.7	Quantities of Fuel Used in International Bunkering in 1994
Graph 2.8	Emissions Related to Agricultural Activities
Graph 2.9	Emissions Associated with the Field Burning of Agricultural Residues and o
	Direct N_2O Emissions for Agricultural Soils
Graph 4.1	Global Mean Concentration of CO_2, Based on IPCC GHG Emissions Scenarios 92c, Amended for IPCC 1995 and SO_2 Regionalized Aerosol Effects
Graph 4.2	Corresponding Scenario of Global Mean Air Temperature for High, Best Guess and Low Sensitivity of the Earth-Atmosphere System to Changes in GHG Concentrations
Graph 4.3	Scenario of Global Sea Level for High, Best Guess and Low Sensitivity of tl Earth-Atmosphere System to Changes in Greenhouse Gas Concentratior
Graph 4.4	Rainfall Patterns for 1983 and 1998

Maps

Inside cover	Map of the Palau Islands
Map 1.1	Political Map of Palau
Map 4.1	Republic of Palau Sea Level Rise 2100 Projections
Map 4.2	Kayangel State Sea Level Rise 2100 Projections
Map 4.3	Koror State Sea Level Rise 2100 Projections
Map 4.4	Peleliu State Sea Level Rise 2100 Projections

Acronyms

BLS	Bureau of Land and Survey
BMR	Bureau of Marine Resources
BoFA	Bureau of Foreign Affairs
BPS	Bureau of Planning and Statistics
BPW	Bureau of Public Works
CASO	Conservation Area Support Officer
CIP	Capitol Improvement Projects
CITES	Convention on International Trade in Endangered Species
CFC	Chlorofluorocarbon
CoP	Conference of the Parties
Compact	Compact of Free Association
COTS	Crown-of-Thorns Seastar
CRRF	Coral Reef Research Foundation
CSIRO	Commonwealth Scientific and Industrial Research Organization
EEZ	Exclusive Economic Zone
ENSO	El Nino Southern Oscillation
EQPB	Environmental Quality Protection Board
GCM	Global Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
ICZM	Integrated Coastal Zone Management
IUCN	International Union for the Conservation of Nature and Natural Resources
IPCC	Intergovernmental Panel on Climate Change
LPG	Liquid Petroleum Gas
MCT	Ministry of Commerce and Trade
MoH	Ministry of Health
MoJ	Ministry of Justics
MoS	Ministry of State
MRD	Ministry of Resources and Development
NECC	North Equatorial Counter Current
NEMO	National Emergency Management Office
NTU	National Tourism Unit

Blenniella chrysospilos - The red spotted blenny is one of over 1,300 species of fishes that inhabit Palau's waters.

OEK	Olbiil Era Kelulau (National Congress)
OERC	Office of Environmental Response and Coordination
OTEC	Ocean Thermal Energy Conversion
PALARIS	Palau Automated Land and Resource Information System
PCAA - IESL	Palau Community Action Agency - Informal Employment & Sustainable Livelihood
PICRC	Palau International Coral Reef Center
PICS	Pacific Island Countries
PPUC	Palau Public Utilities Corporation
SOI	Southern Oscillation Index
SST	Sea Surface Temperature
USGS	United States Geological Service
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
V&A	Vulnerability and Adaptation
VMS	Vessel Monitoring System
WPWP	Western Pacific Warm Pool

Foreword

Tommy E. Remengesau, Jr.
President
of the
Republic of Palau

The island nations of this world are under siege — not by our enemies and not by military forces. The attack comes from our friends, our neighbors and our regional and international partners. Unfortunately, the attackers and their weapons are invisible, even unto themselves. This is because more and larger cars, cooler houses and more convenient home products represent the attack.

This assault is of unprecedented proportion and is expanding every moment. Degraded environments and economies in small island states are merely the first indicator of the potential destruction that this world will face if it does not begin to recognize the problem and take concrete responsive measures.

Global Warming is here. It is not a myth or merely a theory of the scientific community. The climate is changing now, both in the islands and on the Continents. No country and no individual will be immune from its broad and dramatic impact. It is time for the world to see the islands' climate change issues as an omen for the entire planet. The failure of the international community to view the islands as windows into their own futures will ultimately result in their own destruction.

In 1997 and 1998, at least one third of Palau's reefs were destroyed due to climate change related weather events. In some areas, up to 80% of our reefs were lost. Most of our taro crops were also destroyed because of drought and extreme high tides during the same period. These were not theoretical scientific losses. These were actual losses of the livelihoods and potentials of the Palauan people. Soon such devastation will be reflected in the countries of the developed world. I am sure that the industrialized nations will listen and desire to become involved at that point. But, will there be any time left for mitigation, and will there be anything left to preserve?

The solution to global warming is a difficult one. It requires that each of us, from both developing and developed states, be willing to make sacrifices for the good of all. It requires that we simultaneously reflect on what is best for our neighbors, as well as for ourselves, over the long term. For the developing nations, it will require a more rational approach to growth than what was previously enjoyed by the rich nations of this world. For affluent nations, it will require that many of the expenses of the solution be borne out of their pocketbooks.

We must think hard and ask ourselves in what state do we want to pass the Earth on to our children and grandchildren? If we can only acknowledge that we are all part of a single world community, we may come to realize that we currently hold the planet's inheritance in our hands.

Sincerely,

Tommy E. Remengesau, Jr.
President of the Republic of Palau

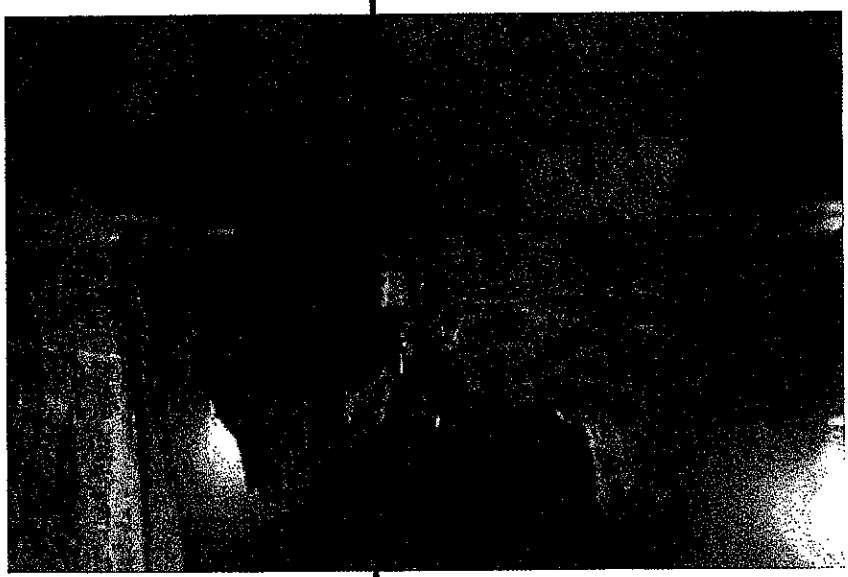
Executive Summary

The Republic of Palau First National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) was developed with the assistance of the Global Environment Facility (GEF) Enabling Activity project.

The Project was initiated in January 2001 and entailed a series of community workshops and a national symposium to: 1) create public awareness regarding the causes of climate change and its impacts on Palau; 2) conduct a greenhouse gas inventory for the period of 1994 to 2000; 3) execute a vulnerability and adaptation assessment to determine the affects of climate change on Palau, identify high areas of vulnerability, and develop a mitigation and adaptation framework to address projected climate change trends; and 4) prepare the Republic of Palau First National Communication to the UNFCCC.

National Circumstances

The Republic of Palau is the westernmost island cluster in the Caroline Island Group. Located in the western Pacific Ocean between 7 degrees North latitude and 134 degrees East longitude, Palau is approximately 800 kilometers east of the Philippines and 800 kilometers north of Papua New Guinea. Due to its location in the Pacific, in combination with other factors, Palau is considered the most biologically rich island group within Oceania. The Palau archipelago stretches over 400 miles in a north-south direction from the atoll of Kayangel to the islet of Hatohobei. Palau consists of 586 islands, of which only twelve are continuously inhabited. Total land area is 535km^2, with 25 percent of Palau's landmass below ten meters above sea level (MoA, 2001). Palau's natural resources consist of one of the largest tropical rainforests in Micronesia, minerals, fossil fuel, natural gas deposits, marine products, and deep-seabed minerals



Chandalier Cave is an example of a limestone cave that was once completely terrestiral. It has since been flooded by water as sea levels have risen over geologic time.

Palau is hot and humid throughout the year, averaging between 74-83°F. Average annual rainfall is approximately 3,810cm, or 150 inches, per year under normal conditions.

Three ocean currents converge in Palau's waters and bring a rich diversity of nutrients that attract a large variety of marine life. These currents also transport larvae of many marine species to the archipelago making Palau's underwater environment one of the most diverse places on Earth.

Cassarina trees grow amongst many of the nutrient poor limestone islands.

Renown as one of the top dive destinations in the World, Palau has developed its adventure tourism sector as its main industry. 1996 figures show that Palau derived US$67 million, or 47 percent, of its Gross Domestic Product (GDP) from its tourism industry. From 1992 to 1997 tourist arrivals doubled from nearly 30,000 to 73,719 (PVA, 2000). However, due to several factors such as the recent Asian economic crisis and the 1998 coral bleaching event, Palau's tourism arrival numbers have been on a gradual decline. This loss is reflected in a 3.3 percent drop in the GDP in 1998. 1998 figures show a 12.9 percent decrease in arrivals, totaling 64,194 for the year. The first nine months of 1999 showed an additional 9.3 percent drop in tourism arrivals when compared to the same period in 1998 (MoA, 2001).

The population of Palau as of 2000 is 19,129, and consists of 13,209 resident Palauans and 5,920 non-Palauan foreign residents (Cencus, 2000). Over the past 10 years, the annual growth rate has fluctuated between 2.3 to 2.6 percent, primarily due to immigration and not from an increase in birth rates within the Palauan community. However, the population is seen to have leveled off at about 2.3 percent in the past two years. Approximately 80 percent of the total population resides in Koror Island, the provisional capitol of Palau. However, a high percentage of the population is expected to shift to Babeldaob once the Compact Road and the new National Capital are completed. The expected completion date of the Compact Road is 2005.

National Greenhouse Gas Inventory

Palau's Greenhouse Gas Inventory shows that Palau was a carbon sink in 1994, meaning that Palau retained more carbon in its forests and vegetation than it emitted during that year. The National Greenhouse Gas Inventory also illustrates that Palau is a minor emitter of greenhouse gases, in both a relative and absolute sense. Consequently, any steps taken to reduce its greenhouse gas emissions, and enhance its carbon sinks, will have a negligible effect on the enhanced greenhouse effect and global warming.

Regardless of any remaining gaps and inconsistencies in the GHG inventory, the message is clear and incontrovertible – the Republic of Palau, and its citizens, are minor players when it comes to greenhouse gas emissions, on either a national or per capita basis. This does not mean that Palau can, or should, sit back and rest on the reputation of being a minor emitter of greenhouse gases. Instead, Palau should strive to be a showcase for the rest of the world by reducing any potential impacts, however minor they may be, on the global climate and related systems.

Definitions

Adaptation is generally referred to by climate change experts as the degree to which systems can adjust in response to, or in anticipation of, changing conditions.

Climate change is the gradual warming of the earth's atmosphere caused by emissions of heat-absorbing "greenhouse gases." The term is generally used to reflect longer-term changes, such as higher air and sea temperatures and sea level rise.

Climate variability reflects shorter-term extreme weather events, such as ENSO. While there is some evidence that climate variability will increase as a result of climate change, many uncertainties still remain.

Greenhouse effect is the combination of greenhouse gases, which together produce a "natural greenhouse effect" that keeps the planet some 30°C warmer than it otherwise would be - essential for life as we know it. Levels of all key greenhouse gases (with the possible exception of water vapor) are rising as a direct result of human acitivity.

Greenhouse gases include water vapor, carbon dioxide, ozone, methane, nitrous oxide, and the chlorofluorocarbons (CFCs). With the exception of CFCs, all the greenhouse gases occur naturally.

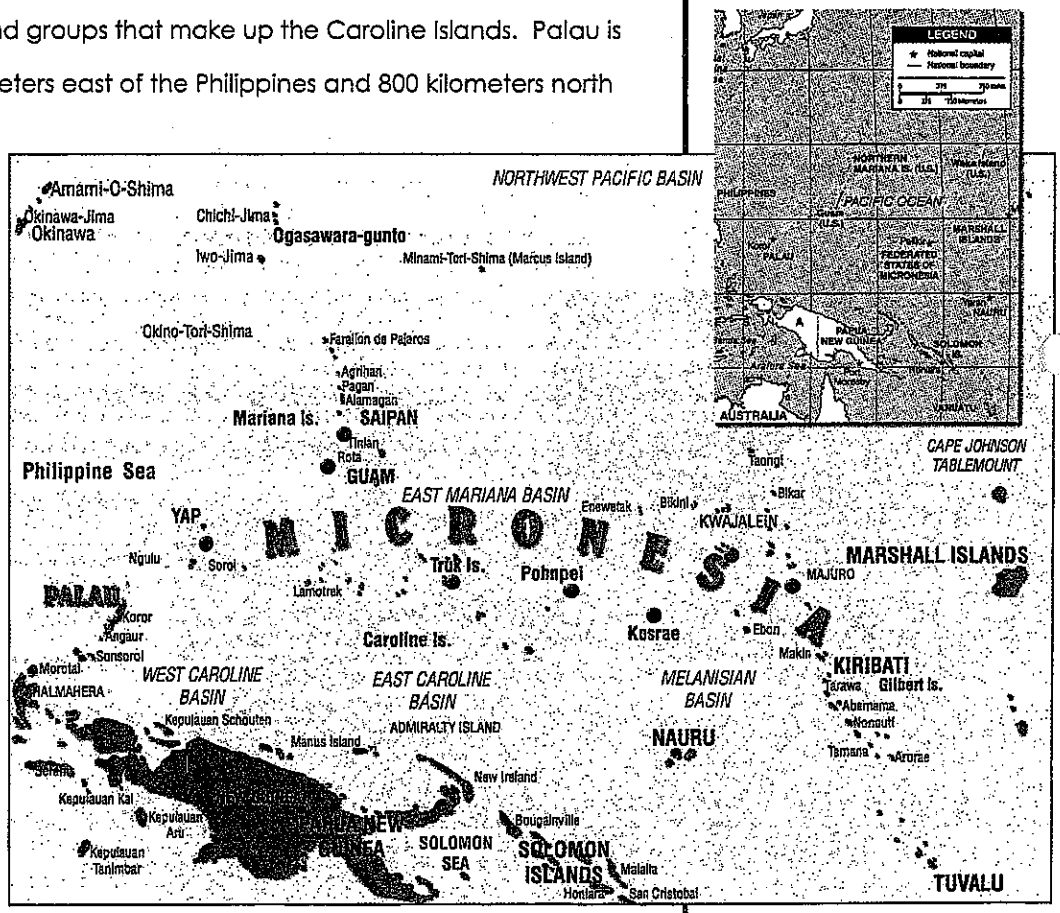
Mitigation is generally referred to by climate change experts to efforts that reduce greenhouse gas emissions.

Vulnerability defines the extent to which climate change may damage or harm a system; this depends not only on the system's sensistivity, but on its ability to adapt.

National Circumstances

1.1 Geography

The Republic of Palau is an archipelago in the Western Pacific Ocean between 7 degrees North latitude and 134 degrees East longitude. Palau is the westernmost island cluster of the six major island groups that make up the Caroline Islands. Palau is located approximately 800 kilometers east of the Philippines and 800 kilometers north of Papua New Guinea.



Although recognized as part of the Caroline island group which features both volcanic and coralline islands, the western Carolines islands are exposed peaks of undersea ridges stretching between Japan and New Guinea and are not located on the Pacific Plate. The Palau islands originated on the now dormant southern section of the volcanic Palau-Kyushu Ridge, which formed about 43 million years ago (mya) in a complex series of rifting and boundary shifts of the Pacific Plate margin during the formation of the Philippine Basin (Kroenke, 1984).

Part of the Oceania group, Palau is located on the eastern edge of the Philippine tectonic plate close to the western edge of the Pacific plate. The Palau, Yap, and Mariana Trenches that mark the subduction zone, where the Pacific plate is being driven under the Philippine plate, are some of the deepest waters on earth. When the islands that make up Palau first emerged above sea level is unknown. However, the

oldest organic limestones have been dated to the early Miocene, which suggests tha the volcanics were emergent sometime before that, perhaps by late Oligocene, som 30 million years ago (Crombie, 1999).

The Palau archipelago stretches over 400 miles in a north-south direction from the ato of Kayangel to the islet of Hatohobei. Palau consists of 586 islands, of which only twel are continuously inhabited. Total land area is 535km^2, with 25 percent of Palau's landmass below ten meters above sea level (MoA, 2001).

The islands of Palau represent five geological island types, volcanic, high limestone, l limestone, atolls, and a combination of volcanics and limestone (Crombie, 1999). The largest islands were formed by Eocene volcanic activity and are composed of basalt and andesite. They tend to have a high profile, well-developed perennial stream systems, and a high diversity of terrestrial flora. Babeldaob island has severely leached and highly acidic soils, unsuited f large-scale agriculture. The world famous "Rock Islands" are of limestone formation. Peleliu and Anguar islands, located at the southern end of the main archipelago, ar low platform and reef islands. The Southw group of islands, located approximately 2 km from the capitol, is made up of reef flo that have been subjected to uplift. Kayangel Island, at the northernmost tip of the archipelago, is a classic coral atoll.

The Rock Islands are comprised of uplifted limestone reefs. They have subsequently been eroded over millions of years by physical, chemical, and biological factors.

Babeldaob island is the largest in the Palau island chain and the second largest islan Micronesia. Babeldaob constitutes 75 percent of Palau's total landmass. At its great

width, Babeldaob reaches fifteen miles across (APCC, 2001). With the exception of Kayangel, Angaur, and the Southwest islands, all of the Palau islands are located within one barrier reef. Palau's exclusive fishing zone is 12 nautical miles, 3 nautical mile territorial seas, with a 200 nautical mile extended fishing zone, which comprises an area of approximately 600,900 square kilometers (Sant/Hayes, 1996).

1.2 History

The date of first human arrival to the Palauan islands is not known, though pottery uncovered in Babeldaob has been carbon dated to about 4,000 years ago. First foreign contact of significance occurred in 1783, with the arrival of the vessel Antelope under the command of English Captain Henry Wilson. Foreign governance of the Palau islands officially began when Pope Leo XIII asserted Spain's rights over the Caroline Islands in 1885. In 1899, Spain sold the Caroline Islands to Germany after Spain's defeat in the Spanish American War. Under German administration, three major economic industries were developed, phosphate and bauxite mining in Anguar and Babeldaob respectively, as well as copra production.

An American tank left behind after World War II serves as a reminder of the thousands who died in Palau during the invasion of Angaur, Peleliu, and Ngedebus Islands.

At the outbreak of World War I, the Japanese government assumed control over Palau in 1914. The League of Nations officially gave Japan control over Micronesia, including Palau in 1920. In 1922, Koror island became the administrative center for all Japanese possessions in the South Pacific. The population reached a record high of 40,000 people, of which fewer than 10 percent were Palauans. During the 1920s and '30s, Japan further developed the phosphate mining industry, and expanded agriculture and fish exports.

In 1947, following World War II, Palau became one of six island districts as part of the United Nations Trust Territories of the Pacific under United States Administration. After thirty years as a United Nations Trust Territory, Palau opted for independence status, in

1978, rather than join the Federated States of Micronesia. A Compact of Free Association with the United States was approved in 1986, but not ratified by the Olbiil Era Kelulau (Palau National Congress) until 1993. The Compact of Free Association, establishing Palau as an independent nation, entered into force on October 1, 1994. The country was admitted to the United Nations (UN) on 15 December 1994 and has since become a Party to a number of international conventions and agreements.

1.3 Climate

The Republic of Palau boasts a maritime tropical rainy climate. Annual mean humidity level is 82 percent. However, temperatures rarely vary more than ten degrees throughout the year. Annual mean rainfall is about 3,810mm per year with seasonal variation (National Climatic Data Center et al, 1996). Palau has two seasons during the year, wet and dry. The wet season typically begins in May and peaks in September. Dry season prevails from February to April and October to December. February, March, and April are the driest months of the year (NOAA, 1991). Although not located within the main tropical cyclone track, Palau has experienced its share of destruction from typhoons and severe storms. Several million dollars of damage was done to Palau's infrastructure as Typhoon Utor swept several hundred miles north of Palau during the summer of 2001.

Surface water is vital to local communities. Approximately three-quarters of Palau's population depends on one watershed for fresh water. Palau's major dam, Ngirikiil (shown above), was severely damaged during Tropical Storm Utor in 2001.

1.3.1 Temperature

Palau's mean temperature is 82°F and fluctuates on a daily basis no more than 10°F (National Climatic Data Center et al., 1996). January and February are generally the coolest months but differ from the warmest month, April, by only 1°F. Seawater temperatures in the main harbor, Malakal, averaged above 29°C for 2000 and 2001

(CRRF, unpublished). The maximum mean sea surface temperature between 1985 and 1999 was 29.55°C (CRRF, unpublished).

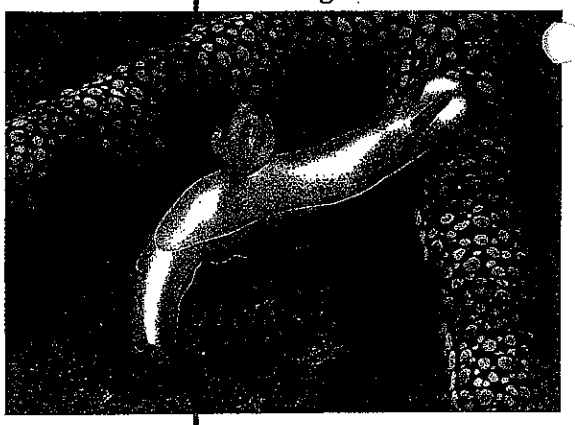
1.3.2 Rainfall

Over the past fifty years, freshwater has been relatively plentiful in Palau. The mean precipitation is 3,810 mm, or 150 inches, per year (National Climatic Data Center et al., 1996). February, March, and April are the driest months with an average of 6 to 8 inches per month. The rest of the year averages between 10 and 20 inches per month. The relative humidity averages 90 percent in the morning and 76 percent in the afternoon (National Climatic Data Center et al., 1996). Predictions indicate that the Caroline Islands, along with some South Pacific Islands may be a region of decreased precipitation in the near future due to the enhanced greenhouse effect, though other model projections predict increased rainfall by 2099 (Morrissey and Graham, 1996; Shea et al., 2001).

1.3.3 Current and Tides

The Palauan archipelago lies in an area influenced by the North Equatorial Counter Current (NECC) and the Mindanao Eddy (Rapaport and Moshe, 1999). Both the NECC and the Mindanao Eddy affect Palau's overall biodiversity by carrying coral and fish larvae originating in the Philippines, Irian Jaya, and Indonesia to Palau (Meyers, 1999). Terrestrial flora and fauna have reached Palau via wind, rafts, or drifting with the NECC.

Hypselodoris bullocki - This nudibranchs' ancestors where originally brought to the archipelago via oceanic currents, as were many marine species. Climate change may alter existing oceanic currents throughout the world, thereby affecting future recruitment of marine organisms.

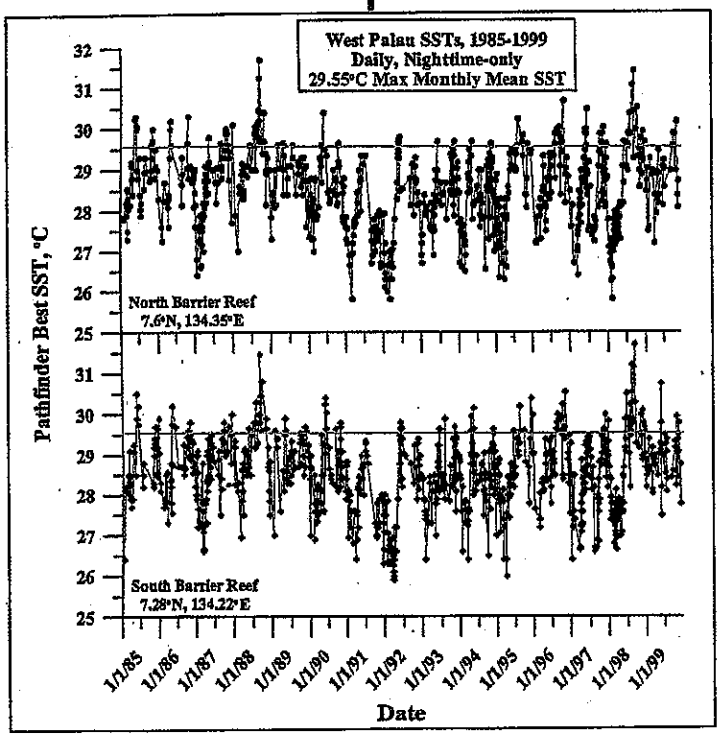


Lunar periodicity dramatically affects the behaviors of fishes and invertebrates throughout the archipelago. Palau experiences semidiurnal tides, or two high and two low tides daily. Spring tides can cause as much as seven feet of exchange, while neap tides may cause as little as two feet of exchange. Over millions of years, tidal currents

have also been one of the factors that have helped shape the physical structure of existing coral reefs around the archipelago.

1.3.4 ENSO Events

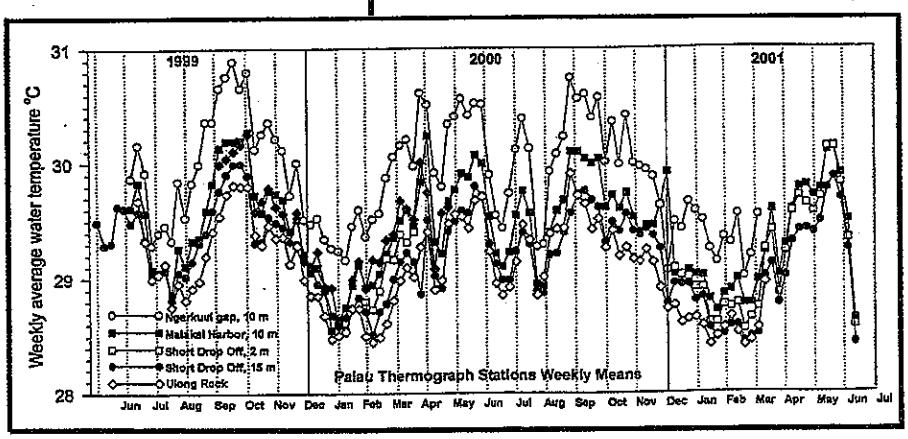
The El Nino-Southern Oscillation phenomenon is an ocean-atmosphere circulation that effects Palau significantly on a regular basis. During an El Nino year, Palau generally experiences drought conditions from weeks to months, and the entire island must ration fresh water. Since little irrigation is done in Palau the agricultural sector absolutely depends on regular rainfall. During the 1997/98 El Nino Palau not only experienced a severe drought but also a significant rise in sea water temperature (Bruno et al., 2001). Over several weeks during August and September of 1998, sea surface temperatures exceeded 30°C (CRRF, unpublished). The unusually warm water caused widespread coral bleachin and had a negative effect on the viability of subsistence fishing.



Graph 1.1: West Palau Sea Surface Temperatures between 1985-1999 show the SST increase during 1998 which caused massive coral bleaching.

Source: Coral Reef Research Foundation

Using model-based climate change scenarios, potential changes in natural climatic variability in the Pacific are predicted over the next century. These changes include the possible emergence of a persistent El Nino-like condition that could affect rainfall, tropical storms and ocean conditions, and, in turn, economically important fisheries and cor reefs (Shea et al., 2001).



Graph 1.2: Natural Variation in Water Temperature. The graphs shows natural variation in water temperature over-time between different geopgraphic sites within Palau's waters.

Source: Coral Reef Research Foundation

1.3.5 Typhoons

There is a potential for the increased occurrence of tropical cyclones, or typhoons, in or near Palau due to climate change. Present tropical cyclone paths, that currently pass about 900 miles north of Palau on average, may be modified due to large-scale changes to circulation patterns (Shea et al., 2001; Pittock et al., 1995). An increase in the number and proximity of typhoons would negatively impact the diversity of Palau's reefs, as well as negatively affect fisheries, which some Palauans still rely on for food security. Many vertebrates and delicate forms of invertebrates that currently habituate in shallow reef areas and related marine ecosystems would be damaged or destroyed by more intense wave action caused by more persistent and frequent storms.

1.4 Biological Diversity

The Republic of Palau is best known for its marine diversity though it also hosts a wide variety of terrestrial flora and fauna, including many endemics. Numerous marine ecosystems exist including mangrove forests, seagrass beds, fringing reefs, patch reefs, barrier reefs, and marine lakes. These ecosystems provide a plethora of marine habitats and even more niches for a huge variety of species to habituate in. Terrestrial habitats include nine types of forests and savannah (Otobed & Maiavia, 1994, Cole et al., 1987). The numerous ecosystems found in Palau provide many goods and services that are crucial to rural communities dependent upon food, fiber, fuel and energy, medicines, clean water, as well as the spiritual, aesthetic and recreational values derived from nature.

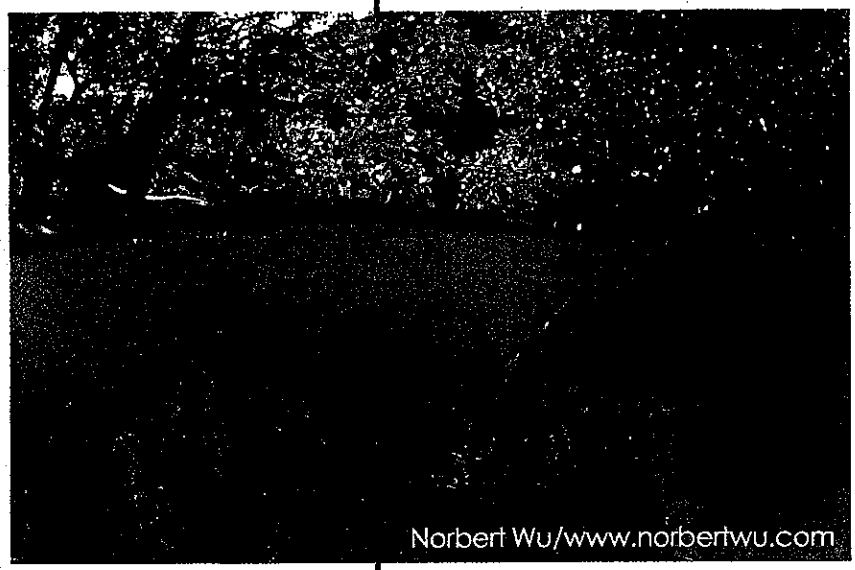
Figure 1.1: Terrestrial and Marine Species List.

Species	Approx. Total	Endemic	Introduced	Endangered
Terrestrial Flora & Fauna				
Plants	1,260	109		
Insects	5,000	500		
Birds	141	16	3	1
Freshwater fish	40	3		
Terrestrial snails		300	1	
Amphibians & Reptiles	46	12		
Frogs	*2*	*1*	*1*	
Lizards	*30*	*10*	*2*	
Snakes	*7*	*1*		
Turtles	*1*			
Bats	3	2		
Marine Habitat & Biota				
Marine Lakes	62			
Soft corals	200			
Stony or scleractinian	385			
Mangrove species	18			
Marine fishes	1,387	11		
Sea grass	9			
Macro-invertebrates	>600	1		
Turtles				2
Saltwater Crocodile	<200			1
Dugon dugon	50-200			1

As of 2002 there are still many unknowns as to the number of marine and terrestrial organisms that reside in and around the Palauan archipelago. This information gap is mainly due to inaccessibility and the lack of capacity for further research. Palau's natural resources, especially its wealth of biodiversity, are subject to many anthropogenic and natural pressures. These pressures include increased demand for resources; selective exploitation or species; land-use and land-use change; anthropogenic nitrogen deposition; soil and water pollution; introduction of invasive species; and fragmentation of ecosystems. Climate change is an added pressure on Palau's ecosystems.

1.4.1 Mangrove Forests

One of the most significant ecosystems found in Palau are mangrove forests. Mangrove cover over 48 km² of Palau, accounting for 11 percent of vegetation growth (Crombie and Pregill, 1999). The most extensive areas of mangrove occur along the west coast o Babeldaob. Mangroves are obligatory halophytes, needing to live in the tidal zones of protected coastlines.



Eighteen plant species are found amongst mangrove habitats in Palau. Mangrove roots often reach above the anoxic substrate in order for each tree to exchange gases.

This type of forest is a vital link between terrestrial and marine ecosystems (Maragos et al., 1994a,b). They act as a filter for significant amounts of sedimentary deposits washed off th islands, especially during the rainy season, keeping the fringing, patch, and barrier reefs from being smothered. Mangroves also protec the islands' shores from erosion caused by wind and waves.

Eighteen species of tree are found in Palau's mangroves, seventeen of them having traditional uses such as medicines, building materials, and handicrafts (Duke, 1999). Th

most common genera include *Rhizophora, Avicennia* and *Sonneratia.* Many reef fishes use mangroves for food and shelter at some point in their life histories (Robertson and Alongi, 1992). Mangroves also provide habitat for Micronesia's only resident population of Indo-Pacific crocodiles (*Crocodilus porosus*), as well as for numerous resident and migrating birds and invertebrates, including the economically valuable Mangrove crab.

1.4.2 Seagrass Beds

Palau contains some of the most extensive seagrass beds in the world, evident along the east coast of Babeldaob. Seagrass slows currents and filters runoff from the islands; thereby keeping fringing and patch reefs relatively clean of sediment. Nine species of seagrass occur in Palau, which provide large areas of primary production (Ogden and Ogden, 1982). Seagrass beds provide vast areas for fish nurseries where many families of food fish preside and feed. Several other organisms important as food sources are found within seagrass beds including *Tridacna* clams, sea cucumbers, urchins, and crabs. The endangered *Dugong dugon* also feeds on seagrasses.

Plectorhincus species - Juvenile reef fishes often use mangrove and seagrass habitats as nurseries. As adults, these fishes move to the outer reef and become part of a more complex food web.

The effects of climate change on this productive ecosystem is not known, though increases of diseases affecting seagrasses in the Caribbean has been reported in recent decades. Diseases and toxicity may negatively impact seagrass beds in Palau due to changes in precipitation frequency and intensity, pH, water temperature, dissolved CO_2, and salinity, combined with anthropogenic disturbances (Gitay et al., ed., 2002).

1.4.3 Coral Reefs

The reefs of Palau include fringing, patch, barrier, and atoll reefs. Reefs cover an approximate area of 1169.4 km² and include a lagoon of 1136.5 km² (Maragos et al., 1994a,b). The immense reef systems were built over millions of years by hermatypic corals. The exact number of scleractinian corals found in Palau is not known but estimates run between 300 and 425 species (Maragos et al., 1994; Veron, 1995; Randall, 1995; Colin, 2001).

There are at least 200 species of cnidarians other than Scleractinia, with many smaller, less conspicuous species undocumented. Over 300 species of sponge have been document, though the total number may be upwards of 500 once the minute and burrowing species are accounted for (Kelly-Borges and Valentine, 1995). The number of marine worms is n known. The total number of Molluscan fauna is not known, though at least 185 species of Opisthobranchs are known and probably over 400 should be expected based on species numbers from Guam, Philippines, and Papua New Guinea (Gosliner, unpublished). Seven species of giant clam (*Tridacna* species) and the endemic *Nautilus belauensis* exist in Palau (Golbuu, 2000). The Crustacean phylum is well represented but it is not known how many species exist in the area. Echinoderm numbers are undocumented, though 21 crinoid species have been documented (Mey and McKurda, 1980). Well over 100 ascidians are found in Palau and up to 150 specie: are expected (CRRF, unpublished).

Amphiprion melanopus - This species of anemonefish became rare in Palau after the sea surface temperature rise during 1998. Its host anemone was bleached and many individuals did not survive the climatic event.

Climate change can potentially affect coral reefs in many ways. A few of the most devastating effects are coral bleaching, the increase of diseases and severe storms, sedimentation, among others. Each of these changes can reduce the overall biodiversity associated with Palau's reefs, thereby causing socioeconomic changes ar creating health issues for the islanders.

1.4.4 Reef and Freshwater Fishes

There are expected to be a total of over 1500 species of fish, marine and freshwater, i Palauan waters, the richest fish fauna in Micronesia (Myers, 1999). Eleven of these are endemic (Myers, 1999). Freshwater endemic species include *Redigobius horiae, Sicyopus fehlmanni, Stiphondon pelewensis,* and *Stenogobius fehlmanni.* The seven

endemic marine species include *Evipes percinctus, Pseudanthias* sp. A, *Cirrhillabrus* sp. A, *Epibulus* n. sp., *Gobidon acicularis, Pleurosicya carolinensis,* and *Kraemaeria cunicularia.* Most species found in Palau are diurnal reef fish (41%). The second most abundant are the cryptic reef fishes (29%), then nocturnal fishes (9%), sand, rubble fishes (9%), mid-water reef fishes (8%), and lastly, pelagic fishes (4%) (Myers, 1999).

Climatic factors affect the biotic and abiotic elements that influence the numbers and distribution of marine organisms, especially fish (Gitay et al., 2002). Variations (with cycles of 10-60 years or more) in the biomass volume of marine organisms are dependent on water temperature and other climatic factors (Gitay et al., 2002).

1.4.5 Marine Reptiles

Marine reptiles in Palau include the Green, Hawksbill, Olive Ridley, and Leatherback turtles (Maragos et al., 1994b; Crombie and Pregill, 1999). Only the Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) turtle populations maintain resident and nesting populations (Maragos et al., 1994b). The Green turtle is listed as threatened and the Hawksbill is listed as endangered by the International Union for the Conservation of Nature and Natural Resources (IUCN). Both species are protected by the Convention on International Trade in Endangered Species (CITES), though both species are hunted for subsistence purposes during particular seasons in Palau.

Crocodylus porosus - The endangered Indo-Pacific crocodile has become a rare site in Palau due to over-hunting in the 1960's and 70's and habitat loss. Vigorous protection in recent years has led to a population increase.

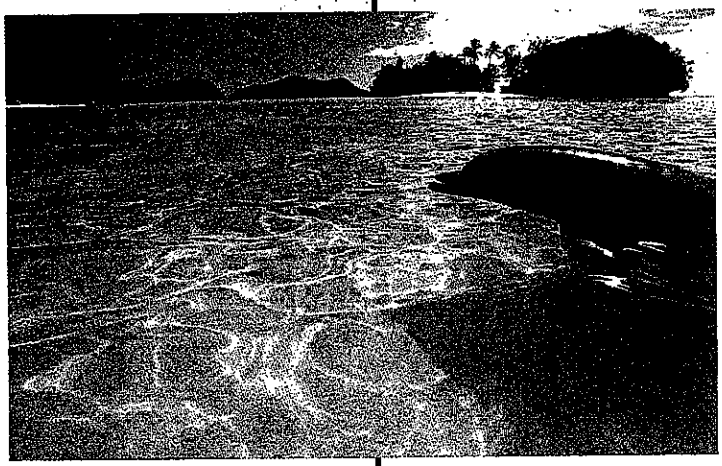
Palau is the only island group in Micronesia that has a resident population of saltwater crocodiles (*Crocodylus porosus*) (Maragos et al., 1994b). This species is on the U.S. Fish and Wildlife endangered species list and protected by CITES (Maragos et al., 1994b). The population was estimated at about 200 individuals in 1991, though local residents

believe there are many more (Messel and King, 1991; Crombie and Pregill, 1999). A new survey of the crocodile population is planned for 2003. Two species of sea snakes, the common banded sea snake, *Laticauda columbrina*, and the extremely rare *Pelamis platurus*, have been recorded in Palau (Crombie and Pregill, 1999).

The major threat to marine reptiles in Palau is habitat loss, both by man-made causes and climate change. Turtle nesting beaches are at risk as sea level is projected to rise between 0.2-0.9m over the next century (IPCC, 2001). Mangrove forests, traditional habitat for crocodiles, are also at risk from sea level rise, increased ferocity and frequency of storms, runoff, and clearing.

1.4.6 Marine Mammals

Palau's dugong (*Dugong dugon*) population is the most isolated in the world (Marsh et al., 1995). The dugong was listed as vulnerable to extinction by the IUCN and protectec by CITES. Dugongs are prone to extinction because they are large, highly prized for food, restricted to localized habitats, and have low biotic potential. The last populatio survey was done in 1991, which found the population to be between 50 and 200 individuals (Marsh et al., 1995).



Marine mammals are frequently encountered passing through Palau's waters. Resident spinner dolphins are often seen near Peleliu and Ngemelis Islands.

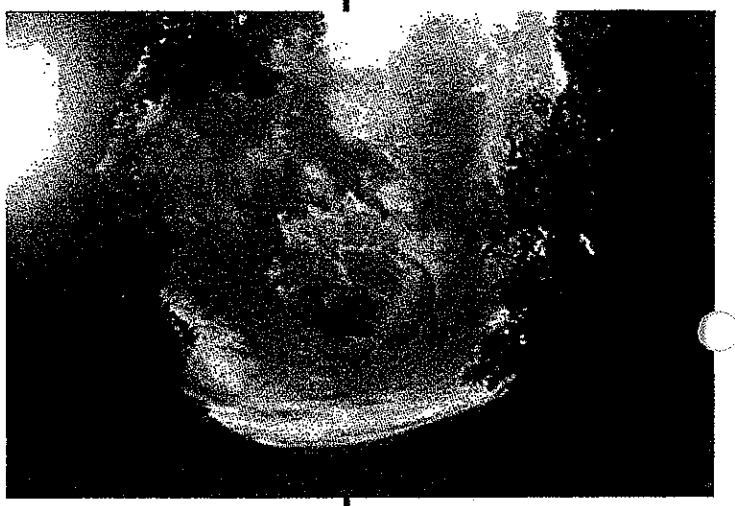
Other marine mammals habituating in Palauan waters include resident Spinner dolphin pods and various other cetaceans. Species that are regularly sited include Pilot Whales, Melon-headed Whales, Risso's Dolphins, Pygmy Killer Whales, False Killer Whale Sperm Whales, and occasionally Orca.

1.4.7 Lake Systems

Palau contains the highest number of marine lakes within a given area than anywhere else known on Earth. Over 60 marine lakes have been created in the Rock Islands via geologic weathering. Each of these lakes is isolated distinct from the next, some being

connected to the lagoon with tunnels or narrow channels. Others are more isolated and completely enclosed by the limestone islands and have little water exchange with the lagoon. The waters in the more isolated lakes have become stratified due to the physical geography, limited tidal mixing, and limited mixing by wind.

Mastigias species of jellyfish inhabit several marine lakes in Palau. These lakes are unique enclosed ecosystems and provide an ideal setting to study climatic events.



Three of the most unusual stratified lakes are popularly known as the Jellyfish Lakes. Each of these lakes contains millions of two species of Scyphozoan, *Mastigias* species and *Aurelia aurita*. The largest Jellyfish Lake is open to the public and receives thousands of visitors per year, while the other two are closed for public use.

Elevated seawater temperatures, caused by the 1998 El Nino-Southern Oscillation (ENSO) event, destroyed millions of the *Mastigias* jellyfish. Fortunately, the *Mastigias* population has rebounded to over eight million during the past two years (CRRF, unpublished). An endemic anemone, *Entacamaea medusivor*, is also found in one of the Jellyfish Lakes. These lakes are extremely important as simplified ecosystems to the scientific community for studying short-term climatic events in the tropics (Hamner & Hamner, 1998).

There are several freshwater lakes found in Babeldaob including the largest in Micronesia, Lake Ngardok. Freshwater organisms found in Palau's lakes and streams include gobies, flagtails, eels, shrimps, crabs, snails, bivalves, and sponges (Rapaport and Moshe, 1999). Saltwater crocodiles are also commonly found in these habitats and Lake Ngardok is considered to be a significant breeding ground for them (Messel and King, 1991).

Climate change may affect freshwater lakes in Palau by reducing oxygen concentrations, usually reducing diversity (Gitay et al., 2002). Eutrophication is another worry via erosion

caused by man-made and natural land degradation. Freshwater ecosystems will be affected by alterations in the hydrological processes. Depending upon the increase or decrease of precipitation in Palau over the next century, productivity in streams and rivers may decrease. Drying of streambeds, due to drought, could reduce ecosystem productivity because of the restricted aquatic habitat and water quality (O_2 concentration) could be reduced (Gitay et al., 2002).

1.4.8 Terrestrial Forests

Nine types of forests are found throughout Palau including Upland Native Forest, Low Coral Island Forest, Raised Limestone Island Forest, and Mangrove Forest. Forests cover 77,248 acres (Otebed and Maiava, 1994; Cole et al., 1987). Agro-forest covers over 2,700 acres and is dominated by coconut stands (Otebed and Maiava, 1994; Cole et al., 1987). Palau's forests are highly valued as watershed areas, for preventing soil erosion, sources of firewood, medicines, building materials, and areas to forage and hunt for food.

Palau is home to the greatest amount of undisturbed forest area in Micronesia. There are over 75,000 acres of forest cover throughout the islands.

Non-forested urban, grassland, and marsh areas cover 21,068 acres (Otebed and Maiava, 1994; Cole et al., 1987).. Grassland/savannah, characterized by a mix of grass (Sword grass) and trees (*Pandanus* species) living in nutrient-poor soil is thought to be the result of human cutting and burning of forests over thousands of years.

Approximately 1,260 species of flora exist in the archipelago, 830 of these being native (Merlin and Keane, 1989; Fosberg et al., 1980). Several hundred species of flora are known endemics. Over 400 specie of alien plants are found in Palau (Otobed and Maiavc 1994). One hundred forty one species of bird exist in Palau, the richest avifauna in Micronesia. Fifty of these species are resident and the others are either migratory or vagrant species.

Several other subspecies of bird may soon be revised as endemics (Pratt, 2001). More endemic skink and gekko species are expected from the Rock Islands due to allopatric speciation (Crombie, personal communication). A number of Palau's endemic species of flora and fauna should be considered prone to extinction as they have specialized habitats, breeding sites, or foods, and some have high economic value.

Some endemics must also compete against introduced alien species for the same resources. Amphibians, in general, can be used as a good yardstick of ecosystem health. Amphibians are extremely sensitive to the environment due to their porous skin and reproductive behaviors.

The frequency of fires are expected to increase in the Pacific due to the effects of warmer temperatures and increased growth of small shrubs and grasses. Climate change is also expected to increase the frequency of pest outbreaks in warm regions (Gitay et al., 2002). Overall, much of Palau's biological diversity is at risk of extinction due to pressures arising from natural processes and human activities. Climate change can only put more pressure on organisms, especially vulnerable and threatened species, though it may relieve some of the existing pressures for a few species (Gitay et al., 2002).

Figure 1.2: Palau Terrestrial Certebrate Endemic Fauna (Crombie and Pregill, 1999; Otebed, 1997)

Common Name	Scientific Name
Gray Duck	*Anas superciliosa*
Palau Ground Dove	*Gallicoluma canifrons*
Palau Scops Owl	*Pyrroglaux podargina*
Palau Bush-Warbler	*Cettia annae*
Palau Fly Catcher	*Myiagra erythrops*
Palau Fantail	*Rhipidura lepida*
Palau Morningbird	*Colluricincla tenebrosa*
White-Breasted Wood Swallow	*Artamus leucorthynchus*
Palau Greater White-Eye	*Megazosterops palauensis*
Blue-Faced Parrotfinch	*Erythrura trichroa*
Palau Fruit Dove	*Ptilinopus pelewensis*
Palau Frog	*Platymantis pelewensis*
Palau Tree Snake	*Dendrelaphis lineolatus*
Pandanus Skink	*Aufacoplax leptosoma*
Rock Islands Gekko	*Gekko sp.*
Gekko species (2)	*Lepidodactulus spp.*
Micronesian Fruit Bat	*Pteropus mariannus pelewensis*
Palau Fruit Bat	*Pteropus pilosus* (probably extinct)
Palau Sheath-Tailed Bat	*Emballonura semicaudata palauensis*

Figure 1.3: Palau Alien Terrestrial Fauna (Otebed, 1997)

Common Name	Scientific Name
Giant African Snail	*Achatina fulica*
Red Junglefowl	*Gallus gallus*
Greater Sulpher-crested Cockatoo	*Cacatua galerita*
Eclectus Parrot	*Eclectus roratus*
Chestnut Mannikin	*Lonchura malacca*
Marine Toad	*Bufo marinus*
Indian Monitor Lizard	*Varanus indicus*
American Cameleon	*Anolis carolinensis*
Non-native Skink sp.	*Carlia sp.*
Polynesian Rat	*Rattus exulans*
Norway Rat	*Rattus norv egicus*
Black Rat	*Rattus rattus*
Himalayan Rat	*Rattus nitidus*
Common Mouse	*Mus musculus*
Asiatic Musk Shrew	*Suncus murinus*
Pig	*Sus scrofa*
Goat	*Capra hircus*
Domestic Pig	*Canis familiaris*
Domestic Cat	*Felis catus*
Crab-eating Macaque	*Macaca fascicularis*

1.5 Population

Palau's current population is 19,129 with an annual growth rate of 2.3 percent (MoA, 2002). The 2002 estimates for the average rate of natural increase is 1.2 percent. Infant mortality is 16.2 for every 1,000 births and the population density per square mile is 110 (MoA, 2002).

1.6 Socio-Cultural Characteristics

The origins of the Palauan people are not known. However, due to linguistic similarities, is generally believed that the islands of Palau were first settled by people migrating fror Southeast Asia and Indonesia around 2,500 BC (Barbour, 1996). Radiocarbon dating of the oldest known village sites located in the Rock Islands and the terraces of Babeldaol date the first to about 1,000 BC (Babour, 1996). There is also evidence of early migratio of Melanesians from New Guinea and Polynesians to Palau (PNM, 2001). The Palauans are believed to be a composite of Polynesian, Malayan, and Melanesian races.

1.6.1 Tradition

By the first foreign contact in 1786, Palau had already developed a sophisticated and highly organized social system. The matrilineal civilization was based on clans and chiefdoms, and these traditions are still carry on in modern society. Original Palauan villages had been situated away from the coast, with piers on waterways leading to the reef-protected tidal flats. Villages were organized by clanships through the female line and subdivided into two political statuses (PNM, 2001). Councils of chiefs from the ten ranking clans of the community governed the villages. Women had an important advisory role and were particularly influential in the control of lanc and money.

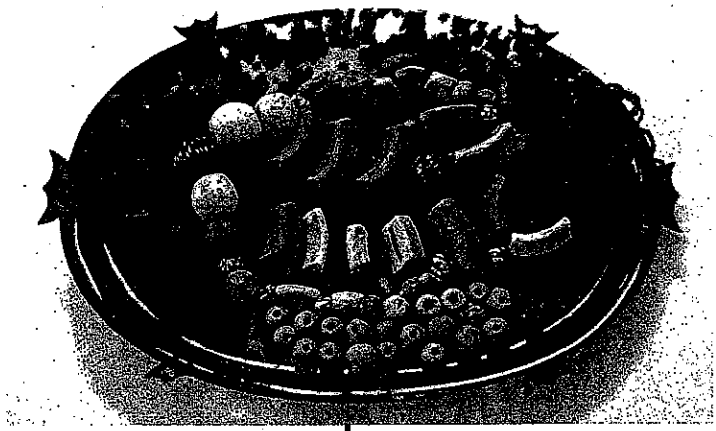
Airai Bai - Traditional mens houses are still used for community discussions amongst 'rubak' and village chiefs.

There were three major facets to the Palauan culture: prestige orientation, competition between individuals and clans, and reciprocity and the manipulation of gifts, money, goods an services. Kinship was the major determinant of social behavior, and each individual in Palauan society, from the moment of birth, had a definite rank in the village, clan, and family. This rank was based on family background and clan ranking, but achievement through individual merit was possible and aggressively sought.

1.6.2 Social System

Present day society in Palau is a complex blend of old traditions and western concepts. Palau has maintained much of its traditional values, but life has changed dramatically with the introduction of western technology and money. Koror State, the provisional capital of Palau, is equipped with westernized infrastructure, such as paved roads, modern stores, and numerous concrete structures. Every residential and commercial structure in Koror State also has access to electricity, sewerage, piped water, and telecommunications.

The central importance of land and money as the root of wealth and power within Palauan society has not diminished with the various foreign occupations of Palau. Palau's intricate system of bead-like money is still actively used both economically and socially in inter-clan payments for important events such as birth, marriage, divorce, and death. Although Palauan money is still used today for ceremonial purposes, land and other commodities are typically purchased using Palau's current means of economic exchange, the U.S. Dollar. Land, for the most part, is considered to be owned by an entire clan and law prohibits foreign ownership of land (Palau Constitution).



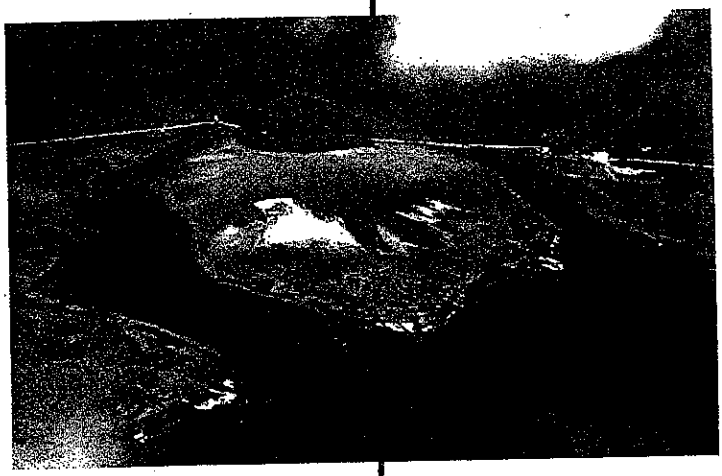
Traditional money beads and Toluk (female money) are still used today for Custom purposes. Traditional money is still highly valued and prized within Palauan society.

1.7 Transportation

Palau currently has 61 kilometers of highways, with 36 kilometers of paved road (CIP, 2002). The major port, Malakal Harbor, is located in Koror Island, the provisional capital city. At present, the country has three airports, but only the Palau International Airport located in Airai State, has paved runways. The Palau International Airport is currently under expansion to accommodate additional air traffic. The completion date of the expansion project is projected for late 2004 (CIP, 2002).

Palau has a series of low-laying causeways connecting several islands to the provincial capitol of Koror. Three of Palau's major causeways that are considered of high economic importance will be severely affected by climate change and sea level rise.

- the causeway connecting Koror to Airai where the Palau International Airport is located;
- the causeway connecting Koror to Ngerkebesang where the Executive Branch of the National Government and National Hospital are located; and
- the causeway connecting Koror to Malakal island where Palau's national maritime port is located.



Causeways connecting the islands are vital to local transportation and economic acitivity. They are at risk from sea level rise and storm damage as climate change

Over the past two decades, the number of cars on-island has increased at a rate of nearly 300 vehicles per year (MoA, 2000). Importation of car parts and accessories, appliances, and prepackaged goods has nearly tripled i the past decade. Currently, only car batteries are reclaimed by the Environmental Quality Protection Boarc (EQPB) and stored until an economically viable means tc export these batteries becomes available. Currently one beverage can recycling operation exists in Palau.

1.8 Energy Sector

Palau currently has one public utilities corporation, Palau Public Utilities Corporation (PPUC), that supplies electrical services to all the inhabited islands. The PPUC is a sem private corporation that manages all of Palau's on-island energy production. PPUC operates an eighteen megawatt and a six megawatt energy plant located in Aimiliik State and Malakal island respectively .

The Aimiliik Power Plant services the islands of Babeldaob, Airai, and parts of Koror; w the Malakal power plan services the islands of Malakal, Arakabasng, and parts of Kc PPUC also services the more remote islands of Kayangel, Peleliu, Anguar, and the Southwest via generators. The PPUC is also exploring other alternative energy option a more cost effective means to provide energy to the outer islands.

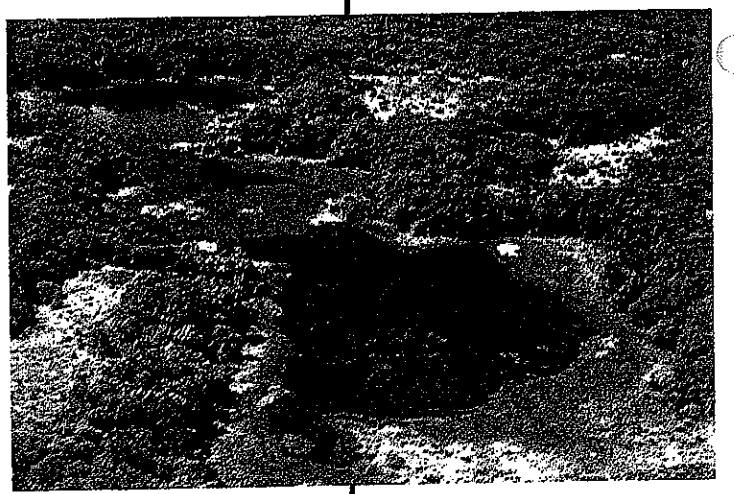
There are two major gas companies in Palau. Both Shell Oil and Mobil Micronesia store fuel near Malakal Harbor and provide bunkering services to various airlines and international fishing vessels. Additionally, three private companies provide Liquid Petroleum Gas (LPG), which is highly used for domestic cooking.

1.9 Water Resources

The primary source of fresh water in Palau is from the atmosphere in the form of precipitation. The pattern of late afternoon rain, rainy seasons, and yearly variations related to global climatic changes such as the ENSO, all affect the availability of rainwater as a resource. Groundwater is found in Palau, though the groundwater lens is thought to be fairly thin and most water pumped from the ground is non-potable. The majority of freshwater used is surface water.

Lake Ngardok is the largest freshwater lake in Micronesia encompassing 0.18km^2 with a storage capacity of 15,000,000 gallons. The longest river in Palau, Ngerdorch River, drains from Lake Ngardok and flows 10km to its mouth. The Ngermeskang River is the second largest river and part of the Ngeremeduu, the largest watershed on the west coast of Babeldaob. The Ngirikiil watershed, located in southern Babeldaob is the main source of water for Palau's population, supplying 4 million gallons of water a day. These watershed areas are highly valued due to freshwater that is collected here. They are also ecologically valuable, supporting wetland vegetation, freshwater species of fishes and invertebrates, nesting birds, and crocodile breeding areas.

Lake Ngardok is considered to be a major breeding ground for the endangered Indo-Pacific crocodile. It is the largest natural freshwater lake in Micronesia.

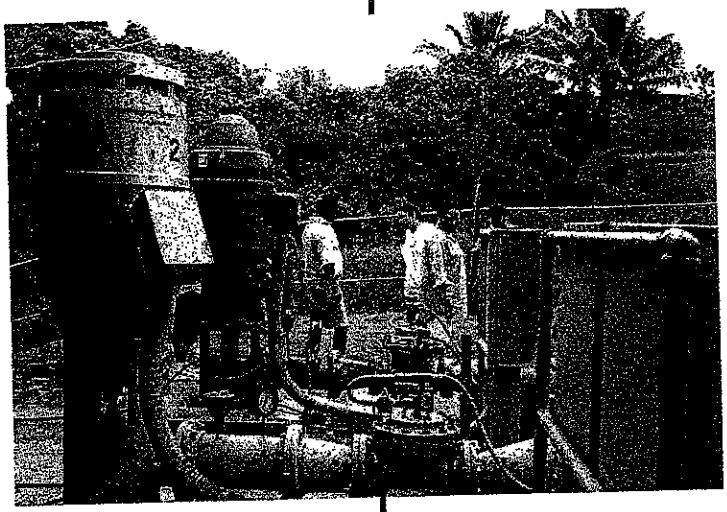


Threats to Palau's water resources include man-made contamination and climate change. Uncontrolled development, poor land uses, and deforestation in combination with intense rainfalls may lead to rapid soil stripping and severe land degradation. There is also the potential a decrease in precipitation over the next century.

The use of fertilizers, herbicides, fungicides, and pesticides are not yet widespread.

1.9.1 Usage

Palau produces 300 billion gallons of water per year from surface water runoff and about 40 billion gallons of water annually from groundwater recharge in Babeldaob. Approximately 110 billion gallons is produced from the re on Palau. A total of 450 billion gallons of internal renewable water is available in Palau (Gonzales, Winzler and Kelly, 2001). The mean rate of water usage per cap per day is 100 gallons per person per day, a consumptio rate of approximately 6.9 million gallons per year for Palau's current population.



Freshwater management remains as the most critical component to the sustainability of Palau's long-term health.

Constraints on water usage are inadequate storage capacities and lack of well-established infrastructures fc distribution. The current water treatment plant in Airai pumps 4 million gallons per dc which 35 to 45 percent is lost through transmission (Marek, personal communication).

1.10 Agriculture

Palau lost an estimated 20 percent of its forests, grasslands, and farmlands due to uncontrollable fires during 1997/98 (MoJ, 2000). During the same year, Palau experienced a 100 percent loss of taro crops (traditional food supply) on the islands Anguar, Pelelliu, and the western side of the big island of Babeldaob (Bishop, 1999). date, the taro patches have not recovered and indicators show that Palau is expec to see an increase in duration and intensity of events such as El Nino and La Nina (IP 2000).

Changing migratory patterns of certain species are causing havoc to Palau's natur environment and social interaction. Invasive alien species have been responsible f decreased production of fruits and vegetable for local consumption and potential export. A 1995 agricultural survey showed that the introduction of the Oriental Fruit

caused up to 100 percent damage to the mountain apple and carambola and 80 percent damage to guava and bananas plants (MoA, 2001).

Although agriculture production has fluctuated since 1995, population has steadily grown at a rate of 2.5 percent from 1995 to the present time. For example, in 1995 fruit and vegetable production totaled 555,964 pounds, 1996 total production was 752,956 pounds, and 1997 total agriculture production was 764,814 pounds. Palau experienced a large increase in agriculture production from 1995 to 1996. Similarly, marginal production change from 1996-1997 shows only a 1 percent increase. However, this 1 percent growth in agriculture production is not compatible with Palau's 2.5 percent population growth rate, which has consistently increased over this period (MoA, 2002). Due to financial and human resource limitations, 1998 was the last year data was collected on Palau's agricultural production.

Palau's agricultural sector, including traditional taro farming, has been negatively impacted in recent years by increased intensity and frequency of droughts, storms, and sea level rise.

During the past ten years, there has been a significant shift from a traditional subsistence lifestyle to a more western style economy. A high percentage of young Palauans are professionally employed in trade and industry. This shift has escalated the growth of foreign labor commercial farming companies that conduct large-scale agricultural production.

1.10.1 Import Dependency

Palau imports all its energy generating requirements. In 1990/2000, there was sharp increase in imports reaching nearly 110 percent of GDP. This sharp increased was primarily due to capital improvement goods such as metal products, machinery, and equipment (IMF, 2002). Imports of fuel, food, and beverages, together accounted for 28 percent of total imports. This figure also increased to about 45 percent during 1999/2000. Imports are estimated to have declined by 25 percent in 2000/2001, as most construction-related goods have already been imported.

In comparison, Palau's exports, accounting for about 10 to 15 percent of GDP, consist mostly of fish (sashimi-grade tuna) and one foreign-owned garment manufacturing company.

1.11 Health

Palau has a comprehensive health care system. Basic public health and medical care is available at the Palau National Hospital. The Bureau of Public Health also services the outlaying States with seven satellite medical facilities. Two additional private medical clinics also provide comprehensive health care. Palau also has a well-developed health care referral program to hospitals in the Philippines, Guam, and Hawaii.

1.12 Economy

As with many small island countries, Palau faces many economic constraints deriving from geographic isolation, a small domestic market, lack of adequate infrastructure, high vulnerability to external and natural stresses, and a narrow resource base in terms of its natural, financial, and human assets.

Due to its past status as a UN Trust Territory under United States administration, Palau's currency is based on the US Dollar. Palau's main income sources are from the Compact of Free Association (the Compact) payments, tourism, trade, subsistence fishing and agriculture production, and services mainly derived by the public sector (BOH, 2000). The Compact payments, which are scheduled to end in 2009, constitute the largest income for the Republic.

Figure 1.4: Palau's Major Economic Indicators.

Indicator *(even years)*	1994	1996	1998	2000
Population	16,783	17,680	18,500	19,129
Population growth (%)	2.6	2.6	2.0	2.3
Life expentacy	69.5	68	70.9	70.5
Crude birth rate (per 1,000 population)	22.28	20.17	15.14	13.45
Infant mortality (per 1,000)	21.98	18.55	9.82	18.25
Life expectancy at birth (both sexes)	69.46	68.02	70.89	70.48
Total fertility rate (average)	2.7154	2.441	1.8081	1.535
Non-resident workers	...	...	4,269	6,786
GDP (in million U.S. Dollars)	84.6	108,204	117,320	118,206
GDP per capita	5,042.60	7,028.40	6,986.60	6,127.00
Average wage rate ($yr/per worker)	7,101	7,193	7,687	8,520
Unemployment (%)	2	2.1	2.1	2.3
Forest cover (%)	76	76	76	...

Sources: Bureau of Budget and Planning

1.12.1 Compact of Free Association

The Compact of Free Association is a 50-year political, strategic, and economic treaty between the Republic of Palau and the United States. Under the Compact, Palau conducts its own domestic and foreign affairs as any sovereign nation, while the United States retains control of defense and security matters as well as exclusive strategic access to Palau's waterways. In return for this access, the United States agreed to pay the Republic approximately US$630 million during the first 15 years of the Compact (1994-2009). However, this sum is not completely monetary, but a combination of economic and technical support. To date, over half of the Compact payments have already been paid to the Republic.

1.13 Tourism

Currently the main industry in Palau is adventure tourism. In 1996, Palau derived US$67 million, or 47 percent of the GDP, from its tourism industry. From 1992 to 1997, tourist arrivals doubled from nearly 30,000 to 60,000. However, due to several factors, including global warming, Palau's tourism numbers have been in decline since the 1998 coral bleaching event. This loss is reflected in a 3.3 percent drop in the GDP in 1998. In 2001, Palau started to see a slight increase in tourism arrivals. However, the numbers of tourists visiting Palau annually are still far below 1997 tourist arrivals.

Figure 1.5: Palau's Tourism arrival trends for the period between 1994-2000.

	1994	1995	1996	1997	1998	1997/98 % change	1999	2000
Tourists			58,022	63,601	59,780		45,462	42,470
Business			2,697	2,840	3,876		3,708	3,462
Employment			3,347	3,425	3,926		3,746	5,064
Other			5,264	3,853	1,346		3,944	5,506
TOTAL	44,073	53,229	69,330	73,719	68,928	-12.9	56,466	56,502

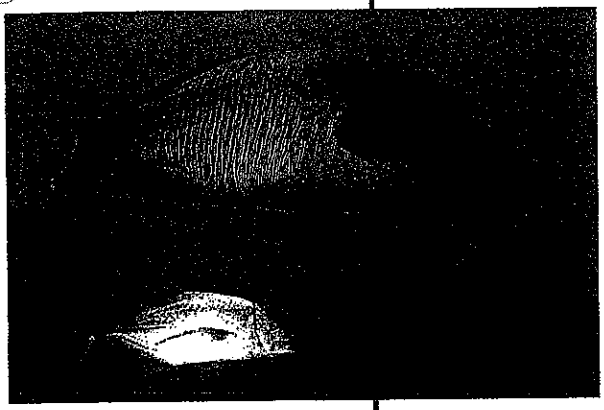
Source: Palau Visitors Authority

To address this issue, the Executive Branch initiated the 2002 National Committee on Sustainable Tourism Policies and Action Plans to review the various strategic and management plans for the development of Palau's tourism sector. The major outcome of the Committee was the development of the National Tourism Unit (NTU), under the Office of the President. The NTU is mandated to facilitate change by implementing a program of coordinated growth, developing policies, and establishing new tourism management activities within

the context of sustainable development. The NTU has a two-year programmatic framework to implement the outcomes of the Committee.

1.14 Fisheries

Palau's commercial fishing industry is quite small, with an average annual income of approximately US$3.5 million (BOH, 2000). The commercial fishing industry largely consists of foreign long-lining fishing vessels , mainly targeting tuna, in Palau's exclusive economic zone (EEZ). The sale and processing of the fish is done off-island.



Cheilinus undulatus and *Caranax melampygus* - The Napolean Wrasse and Bluefin Trevally are commonly found along Palau's reefs. Reef fisheries continue to be the major source of protein in the Palauan diet.

Fish exports declined in 1997/98 by about 20 percent as compared to 1995/96. This was primarily due to the government requirement that all fishing vessels install Vessel Monitoring Systems (VMS), as well as the 1997/98 El Nino event (IMF, 2002). Subsequently, fish exports rose by 23 percent in 1998/99 as several neighboring countries also began to require that fishing vessels install VMS. In 2000/01, fish exports are estimated to have fallen again by 33 percent to approximately US$7 million, compared to a peak of US$13 million in 1994/95 (IMF, 2002).

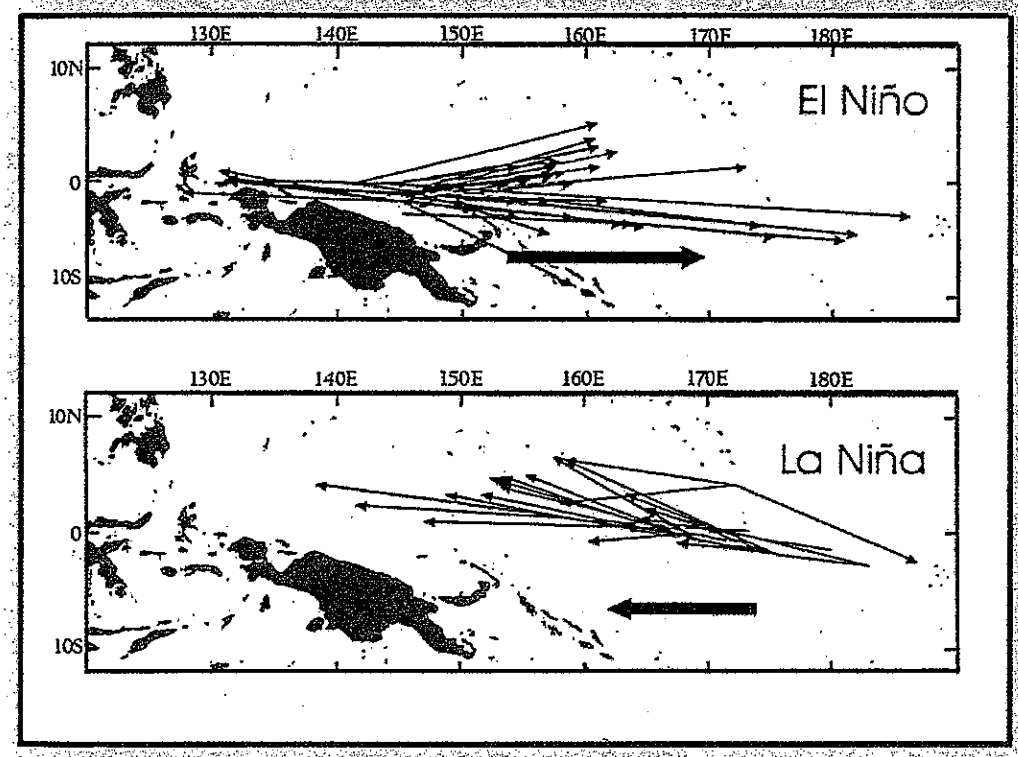
As stated above, it is possible that climate change may affect the migratory fish populations in Palau's waters. The future distributions of these wide-ranging species are difficult to predict. However, climate change may affect regional tuna fisheries in two major ways: by raising average ocean surface temperatures to levels currently experienced during medium-intensity El Ninos and by increasing year-to-year climate variability (World Bank, 2000). The likely impacts are expected to be pervasive, affecting distribution, abundance, and catchability of tuna and other pelagic species.

Primary productivity of tuna in the central and eastern Pacific ocean would decline due to the increased stratification between warmer surface waters and colder deeper water. The decreased upwelling may induce a decline in bigeye and adult yellowfin populations. However, skipjack and juvenile yellowfin tuna are not expected to be affected.

Tuna Fisheries and Climate Variability

The distribution of tuna fisheries is affected by the location of the Western Pacific Warm Pool (WPWP), an area of warm surface water that produces virtually all the tuna caught by purse seine, a fishing method used to collect surface tuna for canning. By itself the WPWP is nutrient poor. By contrast, the colder waters of the central equatorial Pacific generate an upwelling of colder, nutrient-rich waters, that produce the deep water sashimi grade tuna across the whole tropical and sub-tropical ocean. These two oceans areas meet in a zonal band called the "cold tongue," the primary productivity of which is strongly influenced by ENSO variability. During El Nino years, the WPWP can extend eastward into the central Pacific by nearly 4,000 kilometers.

Movement of Tagged Skipjack Tuna in the Central and Western Pacific



Source: Lehodey et al. (1997)

Greenhouse Gas Inventory

2.1 Introduction

As a non-Annex I Party to the United Nations Framework Convention on Climate Change (UNFCCC), the Republic of Palau is required to develop, periodically update, and publish its national inventory of anthropogenic emissions and removals of all greenhouse gases not controlled by the Montreal Protocol on Substances that Deplete the Ozone Layer.

2.2 Methodology, Assumptions, and Data

In accordance with decision 10/CP.2 of the Conference of the Parties (CoP) to the UNFCCC, the inventory was prepared using 1994 as the base year. Except were noted, the methods and default values under the revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories were used to determine Palau's greenhouse gas emissions.

Figure 2.1: Completeness of Data for Palau's Greenhouse Gas Inventory

	1994	1995	1996	1997	1998	1999	2000
Energy	✔	(✔)	(✔)	(✔)	(✔)	(✔)	(✔)
Industrial Processes	✔	✔	✔	✔	✔	✔	✔
Agriculture	✔	✔	✔	✔	✔	✔	✔
Land-Use Change and Forestry	✔						
Waste	✔						

Figure 2.2: Integrated Inventory of Annual Emissions for Palau in 1994

		Carbon Dioxide (Gg CO_2)	Methane (Gg)	Nitrous Oxide (Gg)	Nitrogen (kg)	NMVOC (Gg)
Energy		82.11				
Industrial Processes						0.195
Agriculture		3.48		0.02	180.6	0.046
Land-Use	Removals	-424.03				
	Emissions	6.84				
Waste			0.55	<0.01		
Total		-331.6	0.55	0.02	180.6	0.241

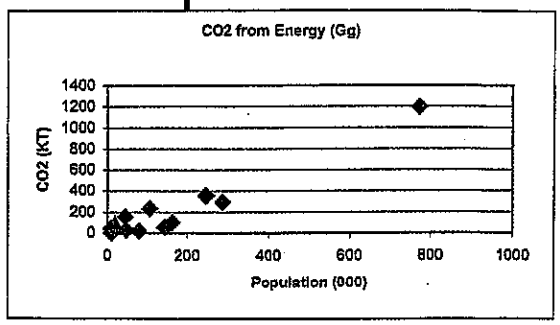
Due to insufficient data availability to carry out a more detailed sectoral approach, the IPCC Reference Approach was used to estimate greenhouse gas emissions from the energy sector. No consideration was given to the sector "Solvents and Other Product Use" as no methodology is provided in the IPCC Guidelines. Additionally, in the case of Palau, emissions from this sector are assumed to be insignificant.

2.3 Results and Analysis

Figure 2.2 quantifies the estimated emissions of GHGs by Palau in 1994. Emissions of CO_2 by the energy, agriculture, and land-use sectors were substantially offset by removals associated with changes in stocks of forests and other woody biomass.

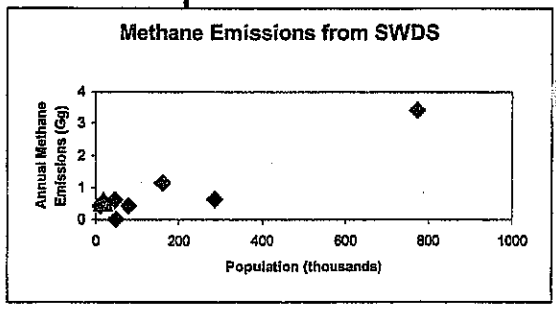
2.4 Quality Assurance

It was possible to assess the level of confidence in some of the emissions estimates by following the procedures used by Hay and Sem (1999). For example, CO_2 emissions from Palau's energy sector are consistent with those of ten other Pacific Island countries, when assessed relative to the national population (Graph 2.1).



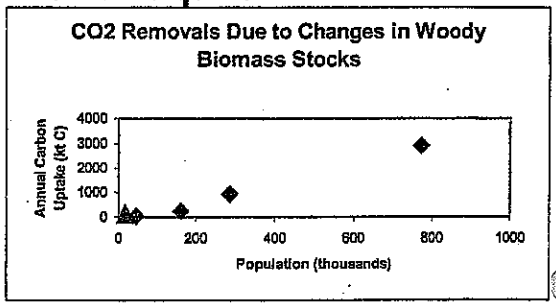
Graph 2.1: Estimated CO_2 emissions from Palau's energy sector in 1994 (shown by red triangle) relative to its national population. Comparable values are shown for ten other Pacific Island countries (after Hay and Sem, 1999).

Similarly, consistent results are found for emissions of methane (Graph 2.2) and for total carbon uptake due to changes in forest and other woody biomass stocks (Graph 2.3).



Graph 2.2: Estimated methane emissions from Palau's solid waste disposal site in 1994 (shown by red triangle) relative to its national population. Comparable values are shown for six other Pacific Island countries (after Hay and Sem, 1999).

It was not possible to undertake compared estimated CO_2 emissions from the energy sector using the IPCC Reference Approach and the more detailed sectoral approach. Insufficient data were available to estimate emissions from the energy sector using the more detailed sectoral approach.



Graph 2.3: Estimated carbon uptake due to changes in forest and other woody biomass stocks in 1994 (shown by red triangle) relative to its national population. Comparable values are shown for six other Pacific Island countries (after Hay and Sem, 1999).

2.5 Uncertainties

The summary overview table in the Revised 1996 IPCC Guidelines was used to report the levels of confidence in the emissions estimates, as well as the status of the emissions estimates, the level of disaggregation of the estimates, and the completeness of the documentation.

In general, reported emissions are for total emissions for all sources (there is no disaggregation), there is medium to high confidence in each estimate.

Figure 2.3: Apparent Domestic Consumption of Fuel and Associated CO_2 Emissions in 1994.

	Apparent Domestic Consumption		CO_2 Emitted
	Tons	TJ	Gg CO2
Gasoline	5966	267.26	18.34
Other Kerosene	316	14.16	1.01
Gas/Diesel Oil	19388	840.07	61.6
LPG	130	6.18	0.39
Lubricants	267	10.73	0.78
Solid Biomass	53	0.83	0.09

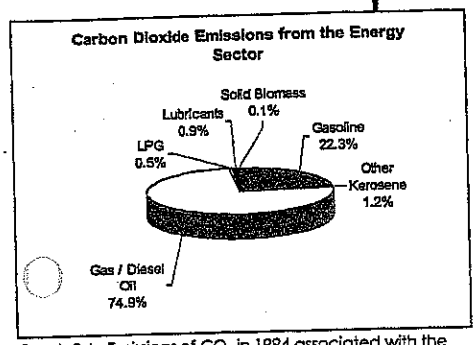
2.6 Greenhouse Gas Emissions by Sector

The national greenhouse gas emissions and removals for all sectors for the baseline year of 1994 and from 1994 to 2000 for

the selected greenhouse gas emissions related to the following sectors: energy, industrial processes, agriculture, and land use and forestry.

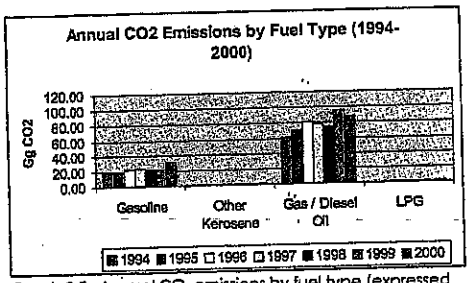
2.6.1 Emissions From the Energy Sector

Figure 2.3 depicts the apparent domestic consumption (i.e. imports combined with domestic production less international bunkering) of fuels consumed within the energy sector of Palau in 1994, including transportation. Graph 2.4 shows apparent domestic consumption (imports combined with domestic production less international bunkering) for 1994 and indicates that the dominant fuels consumed domestically in Palau are gas and diesel oil, followed by gasoline. Other fuels collectively comprise a small portion of national fuel consumption.



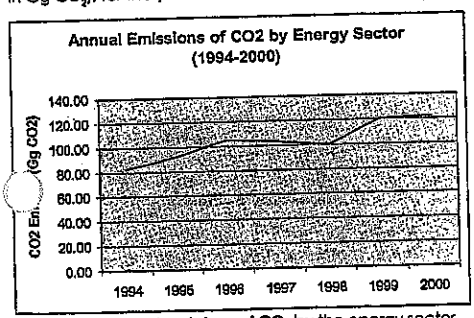
Graph 2.4: Emissions of CO_2 in 1994 associated with the domestic consumption of fuels (expressed in percent).

Total emissions of CO_2 in 1994 amounted to 82.11 Gg CO_2. This is equivalent to emissions of 4.69 tons of CO_2 per capita. A range of 0.23 to 4.60 tons of CO_2 per capita was reported by Hay and Sems (1999) for ten Pacific Island countries and a value of 4.02 tons of CO_2 per capita for the entire world in 1994.



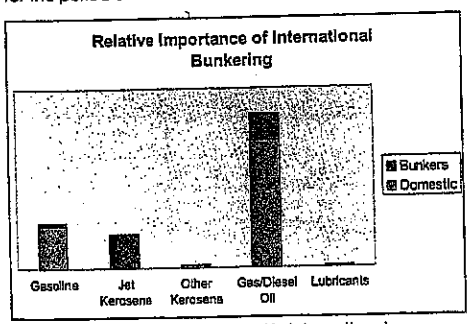
Graph 2.5: Annual CO_2 emissions by fuel type (expressed in Gg CO_2), for the years 1994 to 2000, inclusive.

Annual emissions of CO_2, by fuel type for the period of 1994 to 2000, are shown in graph 2.5. This indicates a substantial and relatively consistent increase in CO_2 emissions by the energy sector over time, a situation that is also demonstrated in Graph 2.6. By 2000, total annual CO_2 emissions from the energy sector had risen to 121.88 Gg CO_2, an increase of 32.6 percent over 1994 values.



Graph 2.6: Annual emissions of CO_2 by the energy sector, for the period of 1994-2000, inclusive.

Graph 2.7 shows the amounts of fuel used for international bunkering, relative to that imported for domestic consumption. Data are for 1994. Similar annual data are available for 1995 to 2000, inclusive. Absolute values are not provided due to confidentiality requirements. All jet kerosene is used for international aviation. Smaller portions of gas/diesel oil, gasoline and lubricants are also used for international bunkering. None of the "other kerosene" is bunkered.



Graph 2.7: Quantities of fuel used in international bunkering in 1994, relative to those imported for domestic consumption.

2.6.2 Emissions from Industrial Processes

Figure 2.4 presents annual emissions estimates associated with soda ash use, road paving with asphalt, alcoholic beverage, bread and other food production, for 1994 to 2000, inclusive. Quantities produced are also shown. Some values may be revised after additional quality controls are applied. Soda ash use was not recorded prior to 1999 and beer production commenced in 1998. In all cases the emissions are small on both a relative and absolute basis, and with varying trends over time.

Figure 2.4: Quantities Involved in Soda Ash Use, Road Paving with Asphalt, and with Alcoholic Beverage, Bread and other Food Production, and the Associated Emissions of Greenhouse Gases.

		1994	1995	1996	1997	1998	1999	2000
Soda Ash Use	Amount (t)						17.9	35.8
	CO2 (Gg)						0.01	0.01
Asphalt	Amount (t)	600	502	712	427	143.5	635	505.5
	NMVOC (Gg)	0.19	0.16	0.23	0.14	0.05	0.2	0.16
Beer	Amount (hl)					70	244	283
	NMVOC (kg)					2.45	8.54	9.91
Spirits	Amount (hl)	17.03	17.03	42.58	42.58	42.58	58.9	80.73
	NMVOC (kg)	255.45	255.45	638.7	638.7	638.7	883.5	1210.95
Cakes etc	Amount (t)	160.81	160.81	160.81	160.81	167.14	167.14	196.19
	NMVOC (kg)	160.81	160.81	160.81	160.81	167.14	167.14	196.19
Bread	Amount (t)	307.34	307.34	307.34	307.34	321.54	320.82	320.82
	NMVOC (kg)	2458.72	2458.72	2458.72	2458.72	2572.32	2566.56	2566.56

2.6.3 Emissions from the Agriculture Sector

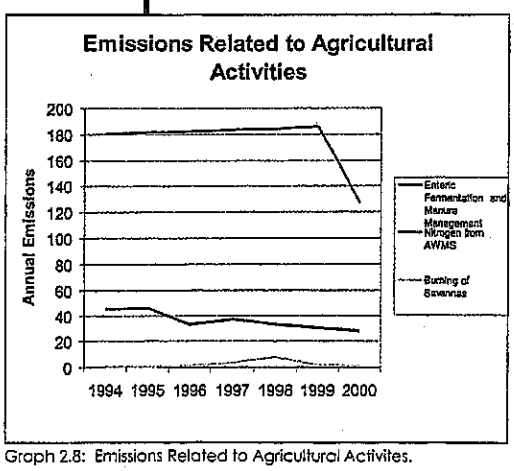
Figure 2.5 depict emission estimates associated with methane emission from enteric fermentation and manure management, nitrogen emissions from animal waste management systems, carbon emissions from the burning of savannas and from the field burning of agricultural residues and of direct N_2O emissions from agricultural soils. Other emissions due to agricultural activities have been estimated and are well within the margin of error and are not reported here.

Figure 2.5: Emissions Related to Agricultural Acitivites.

		1994	1995	1996	1997	1998	1999	2000
Enteric Fermentation and Manure Management	Tons Methane	46.02	46.08	33.54	37.76	33.45	31.38	28.79
Nitrogen from AWMS	kg/N/yr	180.6	181.5	182.4	183.3	184.2	186	126.9
Burning of Savannas	Gg Carbon	0.89	0.54	1.19	3.58	7.75	1.79	1.19
Field Burning of Agricultural Residues	Gg Carbon	0.06	0.06	0.02	0.14	0.07	0.12	0.23
Direct N2O Emissions from Agricultural Soils	Gg N2O	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Graph 2.8 shows emission estimates associated with methane emissions for enteric fermentation and manure management (tons of Methane), nitrogen emissions from animal waste management systems (kg/N/yr), and carbon emissions from the burning of savannas (Gg Carbon).

Graph 2.8 demonstrates the temporal trend of the main emissions associated with agricultural activities, for the years 1994 to 2000, inclusive. In all cases



Graph 2.8: Emissions Related to Agricultural Acitivites.

the emissions are small on both a relative and absolute basis, and with varying trends over time.

2.6.4 Emissions from Land-Use Change and Forestry

Figure 2.6 shows the annual removals of atmospheric carbon associated with land-use activities in Palau, based on a three-year average (ending in 1994), except for the decay of above ground biomass where a ten-year average is used. The release of carbon as a consequence of forestry activities could not be estimated due to the lack of relevant activity data. However, annual emissions are likely to be small due to the low level of forestry activity in Palau. The data for Palau indicate that, in terms of land-use activities, there is a net uptake of carbon.

Figure 2.6: Annual Removals of Atmospheric Carbon Associated with Land-Use Change in Palau and Selected Other Pacific Island Countires.

	Units	Palau	Cook Is	Fiji	Samoa	Solomon Is
Land-use - Carbon Removal	kt Carbon	115.65	42.12	2902	240.19	920.19
	Gg CO_2	424.03	154.44	10641	880.7	3374.03
Biomass Burning – Carbon Released	kt Carbon	0.08		375		
Decay of Above-Ground Biomass – Carbon Released	kt Carbon	1.78		55		
Total Annual Carbon Released from Burning and Decay	Gg CO_2	6.84		2149	125.21	7674

2.6.5 Emissions from Waste

Figure 2.7 presents the annual methane emissions from the solid waster disposal site (SWDS) and as a consequence of wastewater treatment and annual emissions of N_2O from human sewage. Also shown in Figure 2.7 are equivalent data fro other Pacific Island countries for which data are available.

Figure 2.7: Emissions Associated with Waste and Waste Treatment in Palau and Selected Other Pacific Island Countries.

	Units	Palau	Cook Is	Fiji	Kiribati	Marshall Is	Nauru	Samoa	Solomon Is
Methane from SWDS	Gg	0.55	0.01	3.4	0.43	0.62	0.43	1.15	0.63
Methane from Wastewater Treatment	kg	0.11							
N_2O from Human Sewage	Gg	0.0018							

2.7 Comparison with Other Countries

In 1994, emissions of CO_2 by Palau's energy sector amounted to only 0.0004 percent of the global emissions of CO_2 due to energy production. In comparison, Palau has only 0.0003 percent of the global population, reflecting that emissions of CO_2 by Palau's energy sector are above the global average on a per capita basis. By way of contrast, OECD countries had per capita emissions of 11.09, resulting from having 54 percent of the global emissions

despite having only 19 percent of the global population.

Figure 2.8: CO_2 Emissions from the Energy Sector in Comparison with the Rest of the World.

Country/Region	Population (thousands)[1]	CO_2 Emissions from Energy Sector (MT CO_2)[2]	1990 Petroleum Consumption Expressed as Equivalent CO_2 Emissions (MT of CO_2)[3]	CO_2 Emissions per Capita for Energy Sector (tones of CO_2 per capita)[4]	% of Global Emissions	% of Global Population
Palau	17	0.082	0.083	4.69	0.0004	0.0003
Pacific Islands	7100	6.82		0.96	0.0301	0.123
OECD	1092300	12117.05		11.09	54	19
World	5624400	22620.46		4.02		

1 Data sourced from SPREP (1999) and IEA (1998)
2 Data sourced from Palau Inventory, Hay and Sems (1999) and IEA (1998)
3 Data sourced from Johnston (1995)
4 Data sourced from Palau Inventory and Hay and Sems (1999)

Palau is a minor emitter of greenhouse gases, in both a relative and absolute sense. Thus, any steps Palau takes to reduce its emissions, and enhance its carbon sinks, will have a negligible effect on the enhance greenhouse effect and global warming. However, steps should be taken to increase efficiency of existing energy supply systems. Increased efficiency in the current energy supply system, combined with alternative energy, would equate to increased cost savings to the Republic over the long term.

The inventory data collected and analyzed over time should provide an opportunity to quantify the extent to which land use change and changing use of fuels for Custom in Palau are contributing to net increases or decreases in atmospheric greenhouse gas concentrations. Although the magnitude of the resulting changes will be small from the global perspective, the findings will be instrumental in guiding national policies, and implementing plans that achieve larger reductions in global net emissions. Thus baseline and subsequent inventories are fundamental to being able to track the benefits and costs of mitigation strategies that have been implemented over time.

2.8 Data Gaps

Preparation of Palau's first national greenhouse gas inventory identified several gaps and difficulties in applying the Revised 1996 IPCC Guidelines. Many of these culminated in uncertainties in the estimated emissions and removals. To date, the inventory has been completed for all five sectors for 1994. The greatest constraint to compiling the GHG inventory in Palau was insufficient data to adequately calculate actual emissions.

2.8.1 Energy Sector

The IPCC Reference Approach was used to estimate emissions from the energy sector since there is no breakdown of fuel by source category, meaning that detailed technology-based (Tier 1) calculations could not be undertaken at this time. Changes in stock and amount of carbon stored could not be estimated as the required data are not available. In the absence of locally developed values, default values were used for carbon emission factors and for the fraction of carbon oxidized.

There are two major power plants currently supplying Palau's energy needs. Reducing dependance on fossil fuels is a priority of the present Administration.

To date, one of two major fuel importers, has made annual data available for the years 1994 through 2000 for gasoline, jet kerosene, other kerosene, gas/diesel oil, and lubricants. However, data have not been made available by the other fuel importers, requiring these imports to be estimated. This presents a major gap, and hence a significant shortcoming in the confidence of the inventory. Data on imports of LPG for the period of 1994-1999 were estimated using IPCC defaults. LPG data for 2000 was made available for the inventory.

Estimates of biomass consumption were made using procedures in accordance with IPCC guidelines, and relates only to firewood used for lime production, funerals, births, and other Custom. While the number of births and deaths were available from official census records, all other variables represent crude estimates at best.

2.8.2 Industrial Processes

The assumption that emissions relate only to four industrial activities (soda ash use, asphalt production, alcoholic beverage production, and production of baked foodstuffs, relevant to Palau must be verified. In the absence of locally developed values, default values were used for all emission factors and for other relevant variables. It was assumed that the only domestic use of soda ash was for the Koror-Airai Water Treatment Plant. Data was available for 1999 onwards, when the Plant went on-line. However, annual consumption data of soda ash used at the Water Treatment Plant must be reconciled with important records.

The inconsistency in activity data related to road paving with asphalt needs to be reconciled, rather than rely on information provided by one domestic construction company.

At this time, emissions arising from alcoholic beverage production and bread production and other food production are small on an absolute and relative basis.

2.8.3 Agriculture

In the absence of locally developed values, IPCC default values were used for all emission factors and for other relevant variables. Numbers of animals for each livestock type are available for 1996 and 1999 only, requiring forward and backward extrapolations for 1994, 1995, and 2000. Emissions estimates will need to be revisited for 2000 when the official statistical data for that year becomes available.

In the absence of formal data pertaining to forest and savanna fires, the National Fire Department provided estimates for the period of 1994 through 2000. Estimates of the amounts of agricultural residues burned in the field were based on crop data available for 1995 to 1997, only. This necessitated extrapolations for 1994, 1998, and 2000.

Estimates of emissions of nitrogen from agricultural soils also require considerable activity data, as well as the use of default values in the absence of locally derived values. To estimate emissions for Palau, the principal data requirements relate to the amount of nitrogen fertilizer applied annually. Data are available for 1998 and 1999 only. There was no other viable option than to assume similar levels of fertilizer use for earlier years.

Taro (above) and tapioca are traditional sources of carbohydrates in the Palauan diet.

2.8.4 Land-Use Change and Forestry

In the absence of locally developed values, IPCC default values were used for all emission factors and for other relevant variables. The areas of forest and other woody biomass stocks were estimated using information from the 1979 Vegetation Survey of the Republic of Palau. No information was available on commercial harvest of forests and other woody biomass stocks. Traditional fuel wood consumed has been estimated under Energy. Estimates of CO_2 emissions from biomass involved in forest and grassland conversion required information on the area converted. In the absence of more substantive data, a value was prepared using information contained in the

Environmental Quality Protection Board permits issued for developments in Koror and Airai States.

Quantifying the carbon released by decay of biomass requires an estimate of the area converted, averaged over ten years. In the absence of more substantive data, a value was prepared based on the advice of the Bureau of Agriculture. No attempt has been made to estimate non-CO_2 gas emissions resulting from on-site burning of forests. It was assumed that the quantities involved are likely to be insignificant and within the margin of error.

2.8.5 Waste

In the absence of locally developed values, default values were used for all emission factors and for other relevant variables. Currently there is only one solid waste disposal facility that handles solid waste generated by the urban population in Koror State. Methane emissions from this site were estimated, but not those from the several rural and unmanaged solid waste disposal sites that exist in other parts of Palau.

The country's landfill is a major contributor to Palau's GHGs. An effort to develop an effective recycling program is currently underway.

Population census data for 1995 and waste characterization data obtained in 1999 were used to estimate population and waste amounts and composition for 1994. This was the most appropriate and expedient approach, in the absence of other more relevant data. No methane is recovered from the disposal site in Koror State. The methane correction factor was estimated on the basis that the landfill is unmanaged, with the waste being at least 5 meters deep.

The emissions of methane from the treatment of domestic and commercial wastewater used 1994 national data on BOD in wastewater, with the calculated BOD value being the same as the IPCC default value for Oceania. Industrial wastewater is not treated separately, and is included in the total calculations.

The estimate of indirect nitrous oxide emissions from human sewage used the estimated population of Palau in 1994 and annual average per capita protein consumption for th country. The estimated emissions are small and within the margin of error.

Greenhouse Gas Mitigation

3.1 Introduction

The results of the National Greenhouse Gas Inventory provides a comprehensive set of national data that can be used in the preparation of national sustainable development strategies and for assessing the success of these strategies over time. For example, the inventory can assist Palau recognize opportunities to increase the efficiency of existing energy supply systems and to consider opportunities for substituting less costly fuels.

3.1.1 Economic Factors

Economic factors may influence the decision to reduce emissions through increased efficiency of existing energy supply systems and to consider opportunities for substituting less costly fuels. The information available as a result of the greenhouse gas inventory will help determine the cost effectiveness of various options and, in turn, guide the decision-making process as it relates to investment and other initiatives.

3.1.2 Political Factors

Political factors may influence the decision to reduce emissions through improved efficiencies and/or use of fuels that produce emissions with a lower global warming potential. For example, the international standing and credibility of Palau will be enhanced if there is a demonstrated willingness to act in concert with other countries, rather than pleading special circumstances.

3.2 Energy Demand and Use

Palau imports all its energy supplies to meet the demand of its private and public sectors. Palau's social and economic development is highly dependant on its current sources of energy. This aspect of Palau's growth combined with its economic isolation makes large-scale mitigation options difficult at best. However, mitigation measures related to energy consumption in Palau can be subdivided into demand side and supply side options.